W. B. No. 845

U. S. DEPARTMENT OF AGRICULTURE

WEATHER BUREAU

MONTHLY WEATHER REVIEW

VOLUME 52, No. 8

AUGUST, 1924

WASHINGTON
GOVERNMENT PRINTING OFFICE
1924

AUGUST, 1924

CONTENTS

CORRECTIONS

REVIEW, June, 1924:

Page 304, in the article "The So-called Monsoonal Winds of Texas," the author failed to state that Gen. A. W. Greeley, in discussing the winds of the United States, clearly dissents from those who credit that country with monsoonal winds.

REVIEW, July, 1924:

Page 346, the maps, unfortunately disarranged, should be read in the following numerical order: No. 1, the map at top; No. 2, the upper right; No. 3, the upper left; No. 4, the lower right; No. 5, the lower left.

MONTHLY WEATHER REVIEW

ALFRED J. HENRY, Editor

Vol. 52, No. 8
W. B. No. 845

AUGUST, 1924

Closed October 3, 1924
Issued November 8, 1924

PUBLICATION OF SEISMOLOGICAL DATA IN THE REVIEW TO BE DISCONTINUED

Announcement is made that a bill (H. R. 8303), quoted hereunder, authorizing the Coast and Geodetic Survey to make seismological investigations and for other purposes, was introduced in the last Congress, passed by the House of Representatives on June 5, 1924, but failed of passage in the Senate because of the legislative congestion in the closing days of the session:

Be it enacted, etc., That the Coast and Geodetic Survey is hereby authorized to make investigations and reports in seismology, including such investigations as have been heretofore performed by the Weather Bureau.

The transfer as above proposed was fully discussed by the two departments concerned, both of which were agreeable to its enactment.

In view of the necessity of effecting economies in the conduct of the work of the Weather Bureau, it was decided to discontinue, with the close of the fiscal year ending June 30, 1924, the publication of the table of Seismological Reports.—*Editor.*

SUBSTITUTION OF FRUIT TEMPERATURES FOR AIR TEMPERATURES IN REGULATING ORCHARD HEATING FOR ORANGES[1]

By Floyd D. Young, Meteorologist

[Weather Bureau Office, Los Angeles, Calif., August 27, 1924]

Orchard heating has been practiced to some extent in southern California citrus groves for more than 30 years. Throughout all of this period very little has been definitely known regarding the temperatures which will damage the fruit on the trees. The generally accepted critical temperatures are the results of the more or less unsystematic observations of the fruit growers themselves. Many of the thermometers used to record temperatures in the citrus groves have been inaccurate, and until the last few years practically all thermometers were poorly exposed.

Most orange growers who have orchard heating equipment very naturally wish to maintain a margin of safety, with the result that heaters often are lighted unnecessarily, and much fuel is wasted.

When investigations in connection with orchard heating were begun at Pomona, Calif., in the fall of 1917, the desirability of finding a method of eliminating some of the uncertainty regarding the proper time to light the heaters was recognized. Two methods of procedure were available: (1) To obtain accurate records of the air temperature in the orchards on cold nights, with special attention to duration of low temperatures, and to determine the amount of damage to the fruit which resulted; (2) to determine the practicability of regulating the firing by obtaining the temperature of the fruit itself, on the trees.

Data secured in connection with both methods will be discussed in this paper. It is desired to show that although a temperature of 27° F., indicated by an unsheltered thermometer, is generally considered to be the danger point for mature oranges, temperatures several degrees lower than this have occurred on several nights during a season without damage. Temperatures which have caused the loss of the entire crop in an orchard are given also, as a matter of information and record.

It is also desired to show that for efficiency in regulating the lighting of the orchard heaters, fruit temperatures are best; sheltered thermometer readings next; then readings of the unsheltered mercurial thermometer; and, least of all readings of unsheltered thermometers of other types.

LOW AIR TEMPERATURES AND RESULTING DAMAGE

Enough data were obtained during the winter of 1918–19 to indicate that the generally accepted critical temperature for oranges, 27° F., registered by thermometers exposed to the sky, was too high. During that season air temperatures in a naval orange grove were recorded as shown in Table 1. A standard minimum thermometer, exposed inside a fruit-region instrument shelter, 4½ feet above the ground, was used to record the lowest temperature each night, and a 29-hour thermograph recorded the duration of the low temperatures.

Only 3 per cent of the fruit harvested from this grove was so badly frozen as to be unmarketable. Twenty-nine per cent of the crop was frozen sufficiently to prevent its being included in the "Choice" or "Extra Choice" grades. So far as frost damage was concerned, the remaining 68 per cent of the crop was marketable as first grade fruit.

Thermometers exposed to the sky would have registered temperatures from one to three degrees lower than those in Table 1.

Table 1.—*Low temperatures and durations in navel orange groves near Pomona, Calif., winters of 1918–19, 1921–22, and 1922–23*

Date	Minimum temperature	Dew point	Type of night	Duration below 27° F.	
1918–19	°F.	°F.		H	m
Dec. 25	24.2	32	Moderately dry	4	25
30	24.4	[1] 46	Dry	4	40
31	24.1	28	do	9	55
Jan. 1	23.3	21	do	10	42
2	23.1	26	do	9	45
1922					
Jan. 20	19.8	12	do	12	33
21	22.0	22	do	13	0
22	24.6	22	do	8	10
23	25.2	29	Moderately dry	1	45
Feb. 3	25.1	28	do	2	49
1923					
Jan. 3	26.8	33	Damp	0	34
4	25.0	34	do	5	50
14	25.6	41	Very damp	4	30
28	26.6	37	do	0	47
Feb. 4	26.5	28	Damp	2	56
6	26.8	35	Very damp	0	40
7	26.2	38	do	2	5
8	27.0	41	do		
10	25.3	34	do	6	12

[1] Dewpoint fell to 21° F. before morning.

[1] Credit is due Mr. Edwin H. Jones for making the observations shown in Figures 5 and 7, and to Mr. C. W. Norman for making the observations shown in Figures 2 and 4 and a part of those shown in Figures 3 and 6. The writer desires to express his appreciation for the never-failing interest shown by Mr. Jones and Mr. Norman, despite the long hours of disagreeable night work.

FREEZE OF 1922

Warm days, and a lack of frosty mornings, together with the moist soil from heavy rains, kept the citrus trees in a growing condition throughout the winter of 1921–22, and the cold nights late in January probably caused a greater amount of damage than would have been caused in a normal season. As a general rule, the trees become semidormant during the colder winter months, due to the checking of new growth by early light, or moderately heavy, frosts.

Minimum temperatures and the duration of low temperatures in a navel orange grove during the 1921–22 frost season are given in Table 1. The trees in this grove were well cared for, and were in a vigorous condition at the time of the freeze. A heavy crop of fruit was on the trees.

From a close observation of the grove and the fruit on the trees, it is believed that the damage caused by the low temperature on the night of January 19–20 was total. A heavy drop of fruit began on the afternoon of the 20th, and some foliage damage was noticeable. Within two weeks practically the entire crop was on the ground.

1922–23 SEASON

There were very few nights with temperature near the danger point for oranges during the winter of 1922–23,

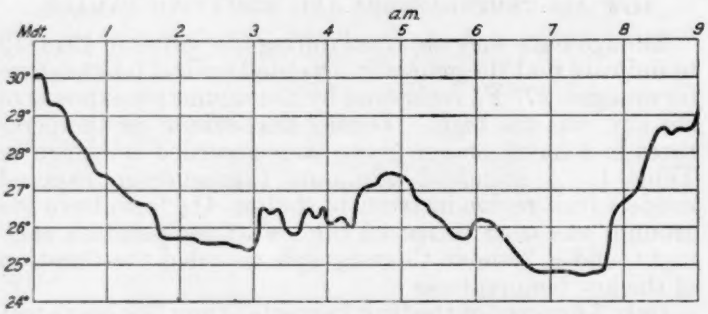


FIGURE 1.—Temperature record at station near Pomona, Calif., night of Jan. 1–2, 1924. Temperature fluctuations due to wind

and there was practically no damage by frost in the Pomona district. A temperature station was established at one of the coldest points in the district, in order to check on the amount of damage resulting from low temperatures. The lowest temperatures in this grove on every night with temperature near the danger point for oranges during the season, together with the duration of temperatures below 27° F., are given in Table 1. Orchard heaters were lighted in the Pomona district on five nights during the season. The firing was light and scattering except on the morning of February 10, when there was general firing up to the foothills.

Careful checks showed no evidence of damage to the interior of any of the fruit in the orchard at any time during the winter. A few "shiners"[1] were noted among the most exposed fruits on the trees, after the colder mornings, showing that the exposed rinds had been frozen, but the fruit itself had not been affected. At the time the fruit was picked, it was given an unusually careful examination at the packing house, but no frost damage was found.

Considering the fact that this particular grove was distinctly colder than the average in the district, it is interesting to note the number of times the heaters were lighted during the season. In the Pomona district alone 243,235 gallons of oil were delivered to the fruit growers during the winter. Probably only a small percentage of this fuel was burned, as most fruit growers carried over large quantities in storage at their ranches. However, when we consider that the amount of fuel consumed in the Pomona district was only a fraction of the total amount consumed in Los Angeles and San Bernardino Counties, it is apparent that the amount of fuel burned unnecessarily represented a substantial expense.

LOW TEMPERATURE WITHOUT DAMAGE

Minimum temperature records in another navel orange grove near Pomona, Calif., during the 1923–24 frost season are interesting because of the lack of damage to fruit. This grove had received excellent care and the trees were in a thrifty condition, with heavy foliage. For several years the grove had been heavily fertilized with bean straw, and the ground was entirely covered with dry bean straw during December, 1923, and January, 1924. The trees were about 15 years old.

Unfortunately there was no thermometer at this station, and the duration of the low temperatures on the different nights is not known. The lowest temperatures recorded at the station on each night during the season when the temperature fell below 27.5° F. are given in Table 2.

TABLE 2.—*Minimum temperatures in navel orange grove near Pomona, Calif., winter of 1923–24*

Date	Minimum temperature	Date	Minimum temperature
	°F.		°F.
Dec. 12, 1923	26.1	Jan. 21, 1924	27.2
Dec. 21, 1923	27.0	Jan. 23, 1924	27.1
Jan. 2, 1924	22.3	Jan. 24, 1924	27.0
Jan. 3, 1924	26.0		

The minimum temperature of 22.3° F., registered on the morning of January 2, was the lowest for the season in the entire district. Light puffs of wind during the night caused the temperature to fluctuate considerably, and it is probable that the temperature was at the lowest point only a short time. A record of the temperature on this night at the nearest station equipped with a thermograph, about a mile distant, is shown in Figure 1.

The fruit in this grove was inspected carefully at short intervals throughout the month of January, without finding any trace of frost injury. The thickness of the rind on the different fruits examined varied from one-eighth to one-fourth inch in extreme cases, with most of the rinds measuring three-sixteenths of an inch thick. The diameter of the fruits varied from 2⅝ to 2¼ inches.

Careful inspection was made of all the fruit from this grove at picking time by packing-house officials. The following is from the report made by the packing-house manager who handled the fruit:

> We have completed the last picking (April 18) and do not find enough frost damage to make mention of. There were very few drops, not over ten boxes on the whole grove. The grade averaged 70 per cent extra choice, 18 per cent choice, and 12 per cent culls. This may seem a little high on culls, but it is due mostly to wormholes and thrip, also quite a few splits.

The lack of damage in this orchard is an extreme case, and it is cited only to show what low temperatures oranges *may* endure without damage. It is probable that the lack of damage was due partly to the lag in the rate of fall in temperature in the fruit behind that of the outside air, and partly to "undercooling," which will be mentioned later. (See fig. 7.)

[1] Oranges on which the portion of the rind exposed to the sky has been frozen, leaving it a lighter yellow than the unfrozen rinds.

FIG. 2.—Fruit thermometer inserted in orange on tree. In actual practice the top of the thermometer would be pointing directly toward the camera

FRUIT THERMOMETERS

It is evident that the orchard heaters are often lighted unnecessarily, due to poor thermometers and poorer thermometer exposures. Even a well-exposed and accurate thermometer is intended to measure only the temperature of the air in the orchard, and the temperature of the fruit may often differ from the air temperature by several degrees. It appeared that a more natural and efficient method of determining when the heaters should be lighted would be to watch the temperature of the fruit instead of the temperature of the air.

In 1918 a special mercurial thermometer, 4 inches in length, made of heavy glass to avoid breakage, and carefully tested for accuracy, was furnished for this work. This type of thermometer was selected in preference to other types because of the fact that it could be used by the fruit growers if the experimental work showed this to be desirable. Several all-night series of fruit temperature readings were secured during the winter of 1918–19, but it was not until the winter of 1923–24 that time was available for making this work a major project.

The latest lot of these thermometers was purchased from the H. J. Green Co., Brooklyn, N. Y. They are graduated from about 20° F. to about 60° F., with an overflow-bulb for high temperatures. The wide temperature scale makes them easy to read. Following a high temperature, the mercury sometimes remains in the overflow bulb at the top of the tube, but it is easily forced back into the tube by whirling the thermometer. The thermometers have no backs, being simply thermometer tubes, somewhat similar to a clinical thermometer. Each instrument is furnished with a hard-rubber carrying case, in which it is well protected from breakage. The price of the fruit thermometer at the present time is $2.50 at the factory. A photograph of a fruit thermometer inserted in an orange is shown in Figure 2.

THERMOMETER EXPOSURES

The observations on which this paper is based were planned to bring out several points in connection with the improvement of orchard-heating practices which the fruit growers had been slow to accept. One of the more important of these is the matter of the exposure of thermometers in the orchards. It is well known that a thermometer exposed to the sky on a clear, calm night loses heat by radiation to the sky, and shows a temperature lower than the actual temperature of the air surrounding it. In other words, the exposed thermometer merely indicates its own temperature. This may be one, two, or even three degrees lower than the temperature of the air at the same elevation in the orchard, depending on the amount of moisture in the air and the type of thermometer used. Generally speaking, dark-colored substances radiate heat more rapidly than lighter-colored substances or those with a high polish. Thus two thermometers, one filled with mercury and the other filled with a dark-colored liquid, will show different temperatures when exposed side by side to a clear sky at night, even though they read the same when sheltered from the sky. With both instruments exposed to a clear sky, the mercurial thermometer will always show a higher temperature than the thermometer filled with dark-colored liquid, because of the higher rate of radiation from the dark-colored instrument.

Most fruit growers have contended that since the fruit on the trees is not sheltered from the sky, the sheltered thermometer will not indicate correctly the temperature of the fruit. As a matter of fact, from 85 to 90 per cent of the fruit on a healthy, vigorous orange tree is well screened from the sky by foliage. The records of the actual temperature of oranges on the trees show definitely that a sheltered thermometer indicates the temperature of even the outside fruit on the tree much more accurately than an exposed thermometer.

FRUIT TEMPERATURES

Records of the temperature inside oranges on the trees, together with temperature records obtained with different types of thermometers and varying exposures, are shown in Figures 3 to 8. Fruit temperatures were obtained by making a very small puncture in the rind of the orange and forcing the bulb of the small fruit thermometer through the rind, until the thermometer bulb was imbedded in the fruit pulp, just under the rind. The thermometer was always inserted at the most exposed spot on the orange, so that the temperatures obtained would be representative of the coldest section of the fruit. When oranges on the trees are only partially frozen, the injury is always found on the fruits on the outside of the tree and in the sections directly exposed to the sky. The careful forcing of the thermometer perpendicularly through the rind into the orange made a tight seal between the rind and the thermometer tube. Any liquid around the puncture was wiped off with a dry cloth.

The records in Figures 3 to 7 show that the mature naval oranges were, during the earlier portion of the night, nearly always warmer than the surrounding air, as indicated by the temperature inside the instrument shelter. Before freezing began, the most exposed oranges on the outside of the trees usually were from two to three degrees colder than those sheltered by foliage.

Temperatures indicated by thermometers exposed to the sky were from one to two degrees lower than those registered inside the instrument shelter. On the night of December 11–12, (fig. 3) the exposed thermometer indicated 27° F. at 11 p. m., while the temperature of the most exposed fruit did not reach that point until 3 a. m. If the lighting of the orchard heaters had been regulated by the unsheltered thermometer, the heaters would have been burned three or four hours unnecessarily.

UNDERCOOLING OF FRUIT

One of the most interesting points brought out in these investigations was the evidence that the juices of the oranges were sometimes cooled several degrees below their freezing point without the formation of ice. Physicists state that distilled water can be cooled many degrees below the freezing point without the formation of ice. Air-free water in sealed capillary tubes has been cooled to a temperature of 3° F. above zero without freezing. The instant the undercooled water begins to freeze, the latent heat liberated causes the temperature of the water to rise to the freezing point, 32° F. The temperature then remains at the freezing point until all the water has been frozen.

In the oranges which were used for these tests, the freezing point of the juice, which is indicated by the point at which the temperature of the fruit remained stationary after freezing had begun, varied from 26° to 28.5° F. The freezing point of the juices of different fruits on the same tree appeared to differ by as much as 1.5° F.

The greatest degree of undercooling occurred in an exposed orange on the night of January 1–2, when its temperature fell to 24.4° F. before it began to freeze.

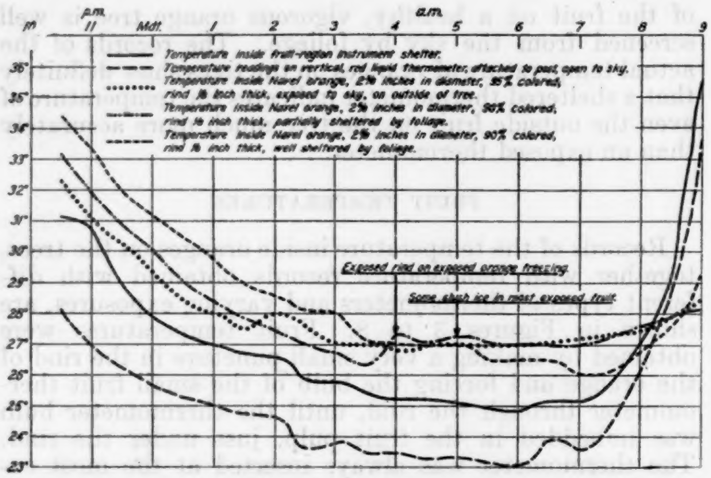


FIGURE 3.—Semihourly temperatures inside sheltered and exposed navel oranges on the trees in an orchard, Dec. 11-12, 1923, together with temperatures indicated by standard minimum thermometer inside instrument shelter, and by thermometer exposed to the sky. Exposed thermometer of a type in use generally throughout the California citrus districts, with black japaned metal case, and filled with a dark-red liquid. Exposed thermometer exposure same as in general use among fruit growers. All thermometers 4½ feet above ground. All had been checked for accuracy

Notes: Light, east wind, with heavy dust during the day on Dec. 11. Cloudless and practically calm all night. General light firing throughout district, with heavy smoke in the morning. Dewpoint 5 p. m. 31.5° F.; 6:30 p. m. 31°; 7:30 p. m. 29°. 1 a. m., heavy frost deposit forming on instrument shelter top. 4 a. m., portion of rind on exposed orange facing sky beginning to freeze (water mark showing). 5 a. m., some slush ice in exposed oranges. Noon, many "shiners" among exposed fruits. Some young and tender shoots killed

Note that the exposed thermometer had shown a temperature below 27° F. for five hours and had fallen to 23.5° F. before the most exposed oranges showed indications of freezing. The rise in temperature inside the partially sheltered orange between 3 a. m. and 3:30 a. m. was undoubtedly due to latent heat liberated in the freezing of the exposed portion of the rind. Oranges sheltered by foliage showed no indications of freezing at any time. They undoubtedly were undercooled. The long period during which the exposed and partially exposed oranges showed a temperature of 27° F. would indicate that their freezing point lies somewhere close to that temperature

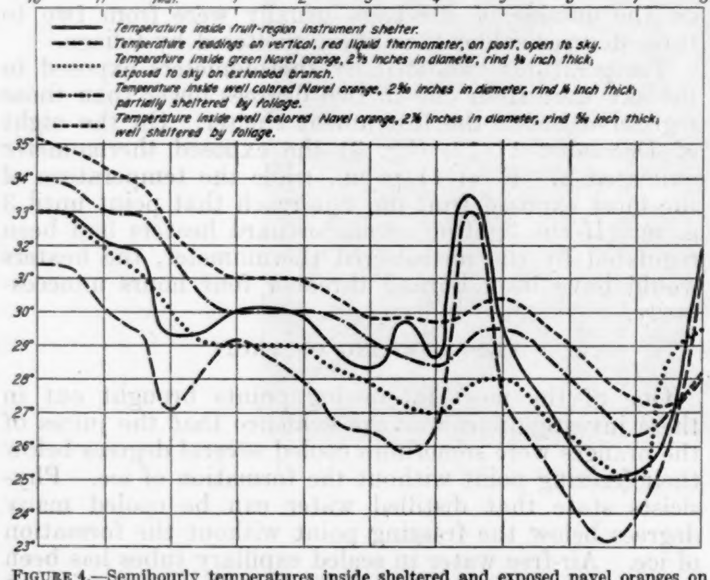


FIGURE 4.—Semihourly temperatures inside sheltered and exposed navel oranges on the trees in an orchard, Dec. 22-23, 1923, together with temperatures indicated by standard minimum thermometer inside instrument shelter, and by thermometer exposed to the sky. Description of instruments and exposures same as in first paragraph under Figure 3

Notes: Cloudless all day and all night, with heavy dust on horizon. Wind in streaks and at intervals during the night caused temperature to fluctuate. Dewpoint 5 p. m. 27° F.; 6:40 p. m. 31°; 7:45 p. m. 30°; 11 p. m. 25°; 2 a. m. 22°; 6 a. m. 23°. Exposed thermometers, leaves, and fruit remained perfectly dry all night. Very light frost deposit on instrument shelter top at 11 p. m.; no frost on ground. 1 a. m., no frost on ground; very little on shelter top. Ground in orchard very dry; evidently surface crust of frozen soil at this time. 4 a. m., thin film of ice forming on shelter top. 6 a. m., surface crust of ground frozen hard. 6:30 a. m., all oranges still soft, with no indication of freezing. 7 a. m., no indications of freezing of any fruit. 8 a. m., sun shining directly on exposed orange, but not on others. Although the exposed thermometer showed a temperature as low as 23.2° F. on this night, there was no indication of damage to any fruit

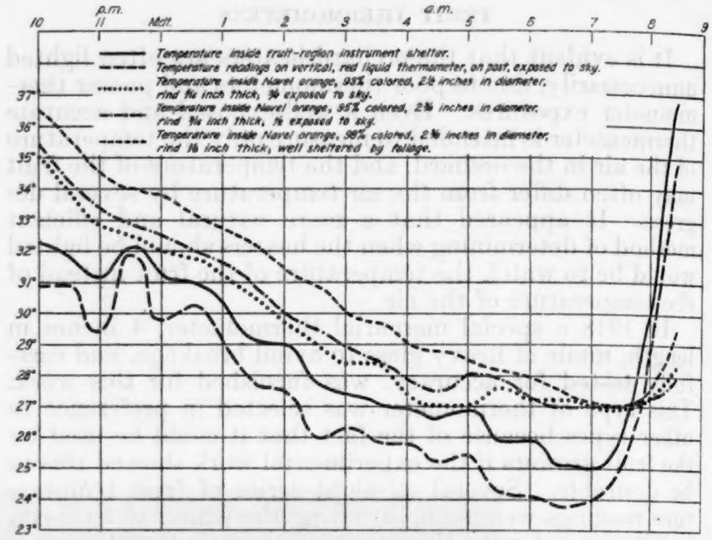


FIGURE 5.—Semihourly temperatures inside sheltered and exposed navel oranges on the trees in an orchard, Dec. 21-22, 1923, together with temperatures indicated by standard minimum thermometer inside instrument shelter, and by thermometer exposed to the sky. Description of instruments and exposures same as in first paragraph under Figure 3

Notes: A few scattering cirrus, cirro-stratus, and alto-stratus clouds during the day and up to 7:30 p. m. Sky cloudless during remainder of night. Light breezes all night caused temperature to fluctuate slightly. Dewpoint 5 p. m. 35° F.; 6:30 p. m. 41°; 7 p. m. 39°; 7:40 p. m. 35°. 10:30 p. m., heavy deposit of dew on exposed thermometers. 2:30 a. m., exposed thermometer completely covered with ice from frozen dew, with layer of frost outside. Necessary to scrape frost from scale to make temperature reading. 5 a. m., portions of rinds of exposed and partially exposed oranges facing the sky beginning to freeze (water mark showing). 7 a. m., all fruits remain perfectly soft. Large water marks on exposed and partially exposed fruits; none on sheltered fruits. Fruits and foliage covered with water or ice, and frost, from 10:30 p. m. until morning. Exposed thermometer showed temperature below 27° F. for five and one-half hours, with a minimum of 23.8°, with no damage to fruit

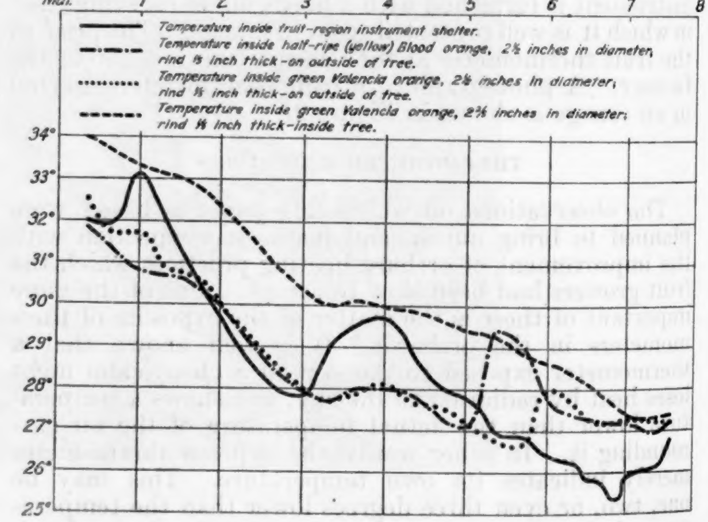


FIGURE 6.—Twenty-minute interval temperatures inside green Valencia orange sheltered by foliage, green Valencia orange exposed to sky, and half-ripe Blood orange exposed to sky, near Lindsay, Calif., on night of Dec. 3-4, 1923; also temperature registered inside thermometer shelter during the same period

Notes: Dewpoint 12:20 a. m. 28° F.; 2:40 a. m. 25°; 4:40 a. m. 25°; 6:20 a. m. 24°; 7 a. m. 25°. 6 a. m., exposed portions of rinds of fruits exposed to the sky beginning to freeze (water mark showing). 7 a. m., sunrise. 7:20 a. m., exposed rinds transparent (frozen) halfway through. No ice in oranges, nor any damage resulting, from this night's low temperatures. Fluctuations in air temperature due to wind. Sharp rises in temperature in exposed fruits between 5 and 6 a. m., probably due to liberation of latent heat in the freezing of the exposed portions of the rinds

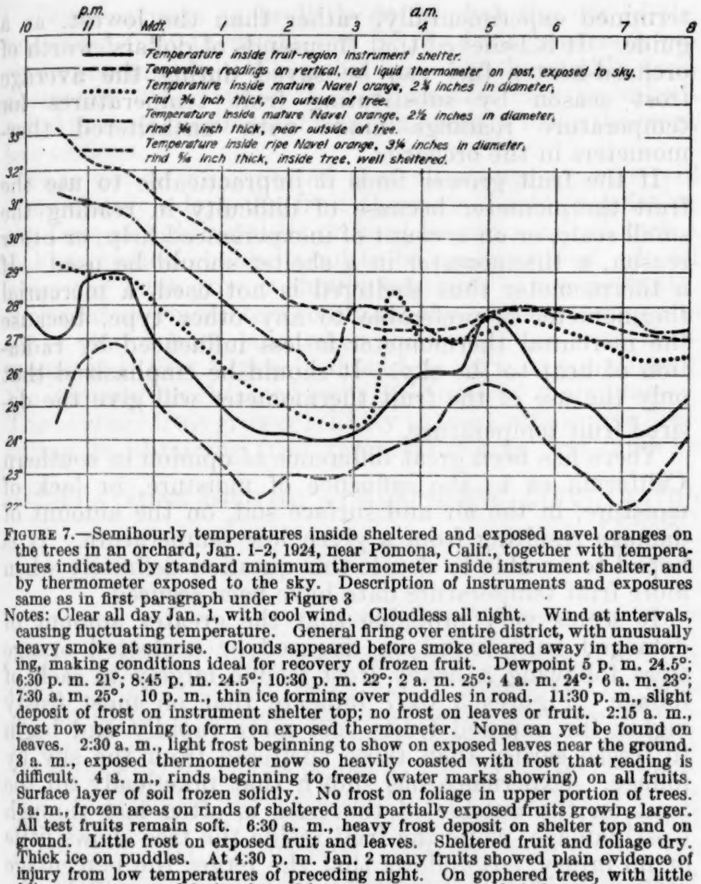


FIGURE 7.—Semihourly temperatures inside sheltered and exposed navel oranges on the trees in an orchard, Jan. 1-2, 1924, near Pomona, Calif., together with temperatures indicated by standard minimum thermometer inside instrument shelter, and by thermometer exposed to the sky. Description of instruments and exposures same as in first paragraph under Figure 3

Notes: Clear all day Jan. 1, with cool wind. Cloudless all night. Wind at intervals, causing fluctuating temperature. General firing over entire district, with unusually heavy smoke at sunrise. Clouds appeared before smoke cleared away in the morning, making conditions ideal for recovery of frozen fruit. Dewpoint 5 p. m. 24.5°; 6:30 p. m. 21°; 8:45 p. m. 24.5°; 10:30 p. m. 22°; 2 a. m. 25°; 4 a. m. 24°; 6 a. m. 23°; 7:30 a. m. 25°. 10 p. m., thin ice forming over puddles in road. 11:30 p. m., slight deposit of frost on instrument shelter top; no frost on leaves or fruit. 2:15 a. m., frost now beginning to form on exposed thermometer. None can yet be found on leaves. 2:30 a. m., light frost beginning to show on exposed leaves near the ground. 3 a. m., exposed thermometer now so heavily coasted with frost that reading is difficult. 4 a. m., rinds beginning to freeze (water marks showing) on all fruits. Surface layer of soil frozen solidly. No frost on foliage in upper portion of trees. 5 a. m., frozen areas on rinds of sheltered and partially exposed fruits growing larger. All test fruits remain soft. 6:30 a. m., heavy frost deposit on shelter top and on ground. Little frost on exposed fruit and leaves. Sheltered fruit and foliage dry. Thick ice on puddles. At 4:30 p. m. Jan. 2 many fruits showed plain evidence of injury from low temperatures of preceding night. On gophered trees, with little foliage, some exposed fruits showed brown spots on exposed rinds, a characteristic indication of frost damage. Many "shiners" on all trees. Note that the temperature of the exposed orange fell to 24.4° F. before freezing began, while the partially exposed orange began to freeze about 30 minutes earlier, at a temperature of 26.1° F. Up to 2:30 a. m. the temperature of the exposed orange was 3.5° lower than that of the sheltered orange, but after freezing began, all three fruits continued at nearly the same temperature. None of the fruits began to freeze until after the exposed thermometer had indicated a temperature of 22.3° F., and had shown a temperature below 27° F. for about five hours

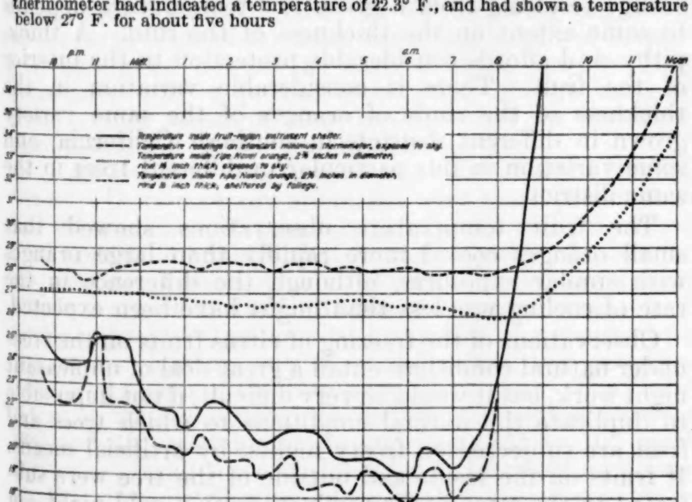


FIGURE 8.—Temperatures inside two mature navel oranges, exposed to the sky, and sheltered by foliage, respectively, on night of Dec. 9-10, 1923, near Lindsay, Calif; also readings of standard minimum thermometers, one inside instrument shelter and the other exposed to the sky in the orchard. Readings made at 20-minute intervals to 8 a. m., then 9 a. m., 9:30 a. m., and noon

Notes: Relative humidity 9:40 p. m., 78 per cent; 11 p. m., 85 per cent: midnight, 90 per cent; 1 a. m., 94 per cent; 3 a. m., 96 per cent; 8 a. m., 98 per cent. 10 p. m., portion of rind on exposed orange exposed to sky frozen. 11 p. m., slush ice in exposed oranges. 4 a. m., leaves curled. 4:40 a. m., exposed fruit firmly frozen. 5:20 a. m., slush ice inside sheltered oranges. 6 a. m., exposed oranges frozen hard. 6:20 a. m., sheltered oranges full of ice. 7:20 a. m., sunrise; smoky. The fruit in the orchard where this test was made was a total loss due to low temperatures on this one night. It is evident from the temperature records that both the sheltered and exposed oranges had already begun to freeze when the observations were begun. It is probable that the more or less constant temperatures which were maintained inside the fruits throughout the night were approximately the freezing points of the juices, or slightly below these points. Although the air temperature was below the freezing point of the fruit juices for 11 hours or longer on this night, reaching a minimum temperature of 19° F., the temperature of the sheltered orange still remained practically stationary at the end of this period, due to the liberation of latent heat.

(See fig. 7.) On the night of December 11-12, 1923, all of the fruits in which temperature readings were obtained began to freeze as soon as the freezing point of the juice was reached, with little or no undercooling. (See fig. 3.)

While the limited number of records at hand makes it impossible to draw any definite conclusions, it appears that ripe navel oranges are likely to be cooled below the freezing point of the fruit on most still, cold nights of winter, but it is not possible to determine in advance what the degree of undercooling will be before the fruit begins to freeze. On the night of January 1-2, 1924, although the temperature of the exposed fruit was running more than 1.5° F. lower than the temperature of the partially sheltered orange on the same tree, the partially sheltered orange began to freeze earlier and at a higher temperature than the exposed fruit. This is shown graphically in Figure 7. As illustrated in Figure 3, there may be no undercooling at all, as the fruit may begin to freeze as soon as its temperature has fallen below the freezing point of the juice.

After the fruit has begun to freeze, its temperature will remain at or near the freezing point of the juice as long as the freezing continues. However, there were some slight fluctuations of temperature inside the fruit after freezing had begun. As a general rule, when the fruit had been undercooled, the temperature rose suddenly several degrees when freezing began, and then fell slightly. This is illustrated in Figure 7. The temperature of the exposed orange fell to 24.4° F. before freezing began, rose rapidly to 28.4° F. on freezing, and then fell back to 27° F. On the same night the temperature of the partially exposed orange fell 1.1° F. after the crest of the rise that took place when freezing began.

There are two possible explanations for this:

1. If the orange is on the outside of the tree, the portion of the rind exposed to the sky always freezes before any other part. When the rind begins to freeze it takes on a peculiar transparent or water-soaked appearance which is quite noticeable. This is known among citrus growers as the "water mark." Very often the freezing does not extend through the rind, but rinds which have been frozen can always be pointed out for at least several days after a freeze. The portion of the rind that has been frozen becomes a lighter color than the unfrozen portion. Such fruits are called locally "shiners." In every case where oranges were undercooled in these experiments, the sharp rise in temperature to the freezing point, due to the release of latent heat, was coincident with the appearance of the "water mark" on the rind. Possibly the moisture in the rind has a slightly higher freezing point than the juice of the fruit, so that the initial rise in temperature at the beginning of the freezing is due to latent heat from the freezing of the rind.[3] If the amount of undercooling has been considerable, the temperature quickly rises to the freezing point of the moisture in the rind when freezing begins, but as the rind is soon frozen through, the temperature falls back to the freezing point of the fruit juice. This is merely a tentative explanation, and has not been verified.

2. After the exposed portion of the rind has been frozen through, the freezing continues in the portion of the fruit directly underneath, in which the bulb of the fruit thermometer was embedded. The portion of the orange facing away from the sky, toward the interior of the tree, is warmer than the exposed portion, because it is sheltered

[3] Since freezing must progress through the rind into the pulp, it does not seem necessary that the moisture in the rind should have a higher freezing point than the juice of the fruit. Temperature during the undercooling would reach a given value in the rind first, and later in the pulp. Hence undercooling would "set off" freezing and the liberation of latent heat first in the rind, with the possibility, as Mr. Young points out, of thus causing a coincident rise of temperature to the freezing point within the fruit.—*B. M. V.*

from the sky, and there must be a conduction of heat from the warmer portions of the orange to the colder exposed portion. (The most exposed segment of the fruit often shows severe injury following a freeze, while the remainder shows no injury.) Assuming that the most exposed portion of the fruit, in which the thermometer is embedded, has been frozen, so that the latent heat in that particular section of the fruit has all been liberated, the only means whereby the temperature in this frozen section is maintained above the temperature of the surrounding air is through the conduction of heat from the unfrozen, or freezing, portions of the fruit. In some cases the rate of conduction of heat may be lowered to the point where the fruit thermometer shows a temperature somewhat below the freezing point of the juice.

The presence of different substances in solution in the orange juice, some of them of a complex organic character, must also have some influence on the freezing point of the orange at different stages in the freezing process.

The large amount of latent heat liberated in the freezing of an entire orange is well illustrated in the records obtained on the night of December 9–10, 1923. (Fig. 8.) Both oranges used in tests on this night had already begun to freeze when the observations were begun, shortly after 9:30 p. m., and probably had been freezing for an hour or more. The total length of time the oranges were freezing on this night was probably about 12 hours, yet the amount of latent heat liberated was sufficient to prevent the temperature of the exposed fruit from falling below 25.9°. The temperature of the sheltered fruit was maintained at about the freezing point of the juice throughout most of the night. The observer states in his notes that the exposed orange was "frozen hard" at 6 a. m., but the freezing evidently was still continuing in some portion of the fruit at that time, since the fruit thermometer showed only a very slight fall in temperature between 6 a. m. and 8 a. m., when the air temperature began to rise.

CONCLUSIONS

The work on the freezing of oranges on the trees under natural conditions, described in this paper, was of a preliminary nature, and the amount of data secured is insufficient to reach any final conclusions. Nevertheless Figures 3 to 8 present an interesting picture of the relationship between the temperatures in the orchard and those inside the fruit, on the particular frosty nights on which the records were made. They should be of value to all orange growers, and particularly to those who protect their crops from frost damage.

The fruit temperature records secured during the winter of 1923–24 indicate that undercooling of the fruit is likely to take place on cold nights, but the degree of undercooling before freezing begins varies greatly, even in different fruits on the same tree, so that when artificial means of heating the orchard are available, it is not safe to allow the temperature to fall below the freezing point of the juice. It is probable that undercooling of fruit, without any freezing, during a cold night, has been responsible for many cases of unusually low temperatures without damage that have been reported in the past.

In determining when it is necessary to light the orchard heaters through the aid of fruit temperatures, it will be necessary for the fruit grower to light the heaters before the temperature inside the fruit has reached the freezing point of the juice. Since this point appears to differ in different fruits, even on the same tree, it will be necessary to take the highest freezing point that has been determined experimentally, rather than the lowest, as a guide. It is believed that thousands of dollars' worth of orchard-heater fuel can be saved during the average frost season by substituting fruit temperatures for temperature readings made with unsheltered thermometers in the orchards.

If the fruit grower finds it impracticable to use the fruit thermometer because of difficulty in reading the small scale, or on account of inexperienced help, or other reason, a thermometer in a shelter should be used. If a thermometer thus sheltered is not used, a mercurial thermometer is preferable to any other type, because the mercurial thermometer is less influenced by radiation of heat to the sky. It should be emphasized that only the use of the fruit thermometer will give the desired fruit temperature.

There has been great difference of opinion in southern California as to the influence of moisture, or lack of moisture, in the air and surface soil, on the amount of damage resulting from a given low temperature. It is hoped to be able to decide this question definitely when more fruit temperature data have been secured.

It seems very probable that the greater amount of damaged fruit found on diseased or neglected orange trees following a heavy frost is due largely to lack of foliage. Figures 3 to 7 indicate that on most frosty nights the exposed fruits cool more rapidly and begin to freeze earlier than those sheltered from the sky by foliage. Experience has shown that practically all the fruit on the outside of the trees is often lost through frost damage, while the fruit inside the tree shows little or no injury. It follows that the larger the percentage of fruit unsheltered by foliage, the greater will be the percentage of loss by freezing, with the same degree and duration of low temperature.

Undoubtedly the amount of damage to a mature orange resulting from a given low temperature depends to some extent on the thickness of the rind. A thick, pithy rind affords considerable protection to the interior of the fruit. There is considerable variation in the thickness of the rinds of oranges of the same variety grown in different districts in southern California, and some variation in this particular in different trees in the same district.

The fruit temperature observations showed that small oranges cooled more rapidly than large oranges with similar exposures, although the difference in the rate of cooling was less than might have been expected.

Observations of the freezing of citrus fruits on the trees under natural conditions entail a great deal of unpleasant night work, but it would be very difficult, if not impossible to duplicate the natural conditions to which trees and fruit are subjected on frosty nights, by artificial means. If fruits on the inside and outside of the tree were subjected to the same cooling influences on a cold night—in other words, if the cooling of the outside fruit by radiation of heat to the sky were absent—artificial methods of freezing trees and fruit might represent very closely the natural conditions. Since no method of duplicating artificially the conditions which occur in the orchards on frosty nights is available, it seems quite necessary that the work outlined in this paper be continued. Experimental freezing of fruit on the trees by artificial means will yield valuable data on the freezing point of fruits, amount of undercooling, and other important points.[3] Some work of this kind has already been done.

[3] Hawkins, Lon A. "Investigations on the Freezing of Citrus Fruit on Trees"; California Citrograph; March, 1924; IX; 163.

There appears to be little doubt that the use of the mercurial fruit thermometers by the fruit growers is entirely practicable. When this has been thoroughly demonstrated, other types of thermometers may be substituted in the experimental work, in order to make the work less tedious.

It is not to be expected that all orange growers will immediately adopt the fruit thermometer for regulating the time of lighting their orchard heaters; indeed such a sudden, radical change is not to be recommended. In all cases the fruit grower should continue to use accurate, sheltered thermometers to obtain the temperature of the air in the orchard, and when the use of the fruit thermometer is first begun it should be only to supplement the information obtained from the sheltered thermometer. The average fruit grower is likely to meet with minor difficulties in obtaining fruit temperatures at first, and he should not depend on such readings until he is sure he thoroughly understands how to use them.

Probably some growers will prefer to continue to use the old methods of obtaining the temperature, if they feel that the men charged with reading the thermometers are not thoroughly trustworthy. On the other hand, the use of the fruit thermometers will not be difficult in any way after the orchard heating crew has become familiar with them, and it is believed that eventually most orange growers will consider them almost indispensable in handling orchard heating.

During the winter of 1923–24 a large number of records was secured showing the temperature inside lemons on the trees during frosty nights, in the same manner as that in which the orange temperatures were secured. The results of these observations will be published later.

OSCILLATIONS OF THE ATMOSPHERIC CIRCULATION OVER THE NORTH ATLANTIC OCEAN IN THE 25-YEAR PERIOD, 1881-1905[4]

By A. Defant

[Innsbruck]

[Translated from the German by W. W. Reed; abstracted and condensed by B. M. Varney]

In the paper: "Die Verteilung des Luftdruckes uber dem Nordatlantischen Ozean, etc.,"[5] were given for each month of the year new charts of mean air-pressure distribution for the whole region covered by the daily synoptic weather charts issued by the Deutsche Seewarte and the Danish meteorological service. Each chart is the mean of the 25 charts of a given month for the period 1881–1905. By the basis of them we may obtain the air-pressure anomalies for that period in the region under consideration. This extensive material furnishes an excellent basis for investigations of nonperiodic changes in the distribution of air pressure as well as of oscillations of the atmospheric circulation over the North Atlantic Ocean and adjacent lands. In the following pages will be set forth some of the most important results of investigations carried out on the basis of these charts. They constitute only a partial elaboration of the material from certain points of view, in order that the investigation should not be too voluminous.

1. *Air-pressure anomalies over the North Atlantic Ocean.*—If we compare anomalies with mean pressures at the intersections of parallels (5° apart) with meridians (10° apart), it appears that in the majority of cases the distribution of the anomaly belongs to a definite system which is a unit in itself. Hence it appeared desirable to confine the investigations to anomalies of pressure over the ocean, leaving out of consideration the extensive adjoining region of the European Continent. The North Atlantic was considered to include the region between 60° and 10° west longitude and from 75° to 10° north latitude. In all there are included 84 intersection points, so that the distribution of anomalies was given by 84 values.

The fact that on the whole the anomaly in the direction of each parallel had the same sign and the same magnitude makes it appear permissible to form mean values in the direction of the parallels for the entire region. Thus we obtain for each month a mean distribution of air-pressure anomaly in a north-south direction between 75° and 10° north latitude. Each value is the mean of the six values between 60° and 10° west longitude. These monthly values give at once a satisfactory view of the kind and magnitude of the departure of air pressure in the month considered, while in their succession they afford a history of air-pressure shiftings over the Atlantic Ocean. This is the first time that a summarized representation of air-pressure departures from normal for a period of 300 months has been compiled for such an extended region of the earth.

In this meridional distribution of air-pressure anomalies over the Atlantic one may very clearly discern the appearance and recurrence of certain characteristic types of anomaly. It is possible, without making too liberal an interpretation of the material, to arrange the 300 successive cases under four types, to which can be assigned indices of intensity of the departures occurring in them.

In type A there lies over the North Atlantic a region of positive pressure anomaly. It extends from the far north to about latitude 50° north, and on an average its center lies near 65° north in the vicinity of Iceland. South of this extends a region of negative anomaly, centered near latitude 40° north, which, gradually diminishing, extends to the thermal equator (10° north latitude). North and south have therefore opposite anomalies, atmospheric pressure in the north being relatively too high and in the south relatively too low. Of the 300 cases, 113, or nearly 38 per cent, fall under this type.

Type B shows the opposite distribution; the negative anomaly reaches from the far north to latitude 50°, with its center at 65°. The positive anomaly extends to latitude 10° north, with its center near 40°. Type B is thus exactly opposed to type A. One hundred and thirty-seven months show the type B distribution, or 46 per cent of all cases. Under A and B occur in the aggregate 83 per cent of all cases. The remaining 17 per cent excepting four cases in which it was difficult to make determination, belong to two other types, which again are opposed to each other.

Type C is related to type A; the positive anomaly usually extends from the far north to 35° north latitude and is centered between 55° and 50° north. The negative anomaly includes the whole southern portion. Twenty-five cases fall under type C. The exactly opposed type D, which is related to type B, appears in 21 cases.

If we combine types A and C, which show a pressure relatively too high in the north and too low in the south, they together include 138 months, or 46 per cent. Under

[4] Geografiska Annaler, 1924, H. 1, pp. 13–41.
[5] Denkschr. der Wiener Akad., Band 93, 1916.

B and D, in which the anomalies are reversed, occur 158 cases, or 53 per cent. The division into these two opposite types is thus nearly equal. A yearly march in the predominance of one or the other could not be determined; their distribution over the individual months is likewise practically uniform. The nature and interrelations of the four types are shown in Figure 1.

From this figure, and from maps not here reproduced, it is seen that these types represent primarily oscillations in the intensity, and to a lesser degree in the position, of the two centers of action in the North Atlantic Ocean, namely, the Iceland LOW and the Azores HIGH. In type A the Iceland LOW is considerably weakened and the Azores HIGH is subnormal; the south-north gradient, which is a measure of the rate of atmospheric circulation in the region, is thereby diminished. Type B, with opposite distribution of anomalies, shows an intensification of the pressure gradient between south and north and thus an increase in the intensity of the atmospheric circulation.

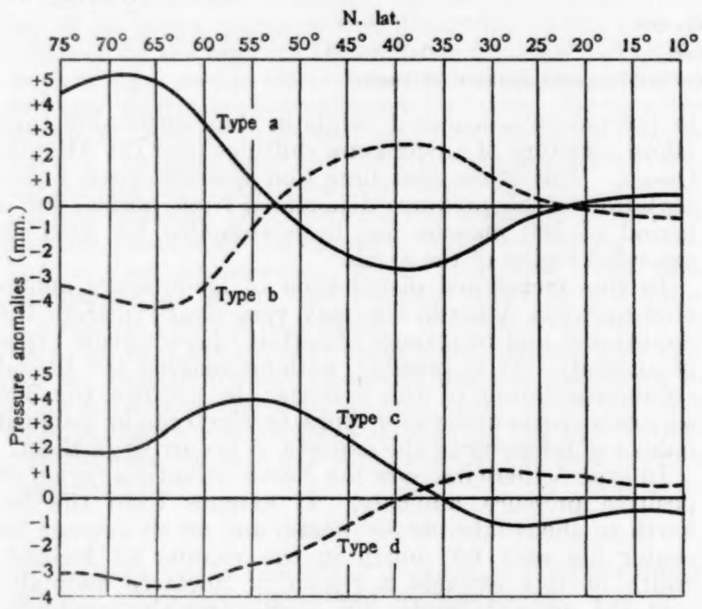


FIG. 1.—Types of pressure anomaly over the North Atlantic Ocean

In connection with the more important types A and B, the question was studied as to what extent positive and negative anomalies compensate each other, or, in other words, whether the deficiency of air mass in the region of negative anomaly probably corresponds to excess in the region of positive anomaly. If this were the case, it would not be too hazardous to assume that these types are produced mainly by the shifting of air masses in a meridional direction. On the basis of a mathematical discussion of the data, it can be said that there is almost complete compensation between north and south. Not only in the yearly means is this the case, but also in the several seasons, though in the latter case not with the same completeness. For the formation of type A, air masses must be shifted from south to north, and for type B from north to south. It is clear that from these strongly characteristic changes of pressure we may draw conclusions as to the intensity of the atmospheric circulation. In the first case the meridional pressure gradients become less steep and the atmospheric machine works with less force, while in the second case the gradients are steepened and the machine works with more force.

2. *The succession of the different types: Oscillations in atmospheric circulation in the years 1881–1905.*—In Table 1 (Table 4 in the original) the monthly values of air pressure anomalies are set forth according to the four types for the 25 years. The attached indices give the intensity of the formation of the type on a scale 0–3, in which there was taken into consideration mainly the amount of the departures;[6] only in a few cases of unusually great anomaly was the index 4 used. The table shows that in certain years the types A and C predominate, indicating intensification of the atmospheric circulation; in others the types B and D, which connote a weakening of the circulation. Because of their close relationship and for the sake of simplicity the types A and C on the one hand and B and D on the other will be combined in the following discussion.

If from Table 1 we combine the frequency of the types into A + C and B + D, it becomes evident that the frequency maxima of the type A + C correspond to the frequency minima of the type B + D, since in each year the two values must amount to 12. Moreover, the march of frequency of both types makes it clear that the pressure anomlies do not follow each other arbitrarily, but that through a rather long series of years first the one and then the other predominates, each oscillation having a period of several years.

TABLE 1.—*Anomalies of atmospheric pressure over the North Atlantic Ocean, 1881–1905*

Year	D[1]	J	F	M	A	M	J	J	A	S	O	N
1881	a_2	a_3	a_1	a_1	b_1	b_1	b_0	d_1	b_0	a_1	b_1	b_2
1882	b_1	b_1	b_0	b_2	a_1	a_0	c_0	b_1	b_0	b_1	b_1	b_2
1883	a_2	d_2	b_1	a_2	b_0	b_0	a_1	a_1	b_1	b_0	b_1	b_1
1884	c_2	b_0	b_1	b_1	a_1	a_1	b_1	a_1	b_1	d_1	b_1	c_2
1885	b_1	d_2	a_3	a_0	a_0	a_1	b_1	a_1	a_2	b_1	c_2	a_2
1886	a_3	c_1	c_1	a_1	a_0	a_1	b_1	b_1	b_1	a_1	b_1	a_0
1887	c_0	b_2	b_1	a_1	a_1	b_1	a_0	b_1	a_0	c_1	a_1	a_1
1888	a_0	a_0	c_1	a_1	c_0	a_0	d_1	a_0	a_0	a_1	a_2	b_2
1889	d_1	a_0/b_0	c_1/b_0	a_0	b_1	b_1	b_2	a_1	b_1	a_1	b_0	b_1
1890	b_0	b_2	b_0	b_1	b_1	a_1	b_0	b_1	b_1	c_0	a_1	b_2
1891	a_0/d_0	c_2	b_0	a_1	a_1	a_0	a_1	b_0	b_1	b_1	b_2	a_1
1892	b_1	c_2	a_2	a_1	a_1	a_1	a_1	b_0	a_0	b_1	a_2	a_1
1893	a_1	a_2	b_2	a_0	------	a_0	a_1	c_0	a_1	a_0	a_1	a_2
1894	b_1	b_1	b_3	b_1	d_1	a_1	b_2	b_1	b_1	a_2	a_1	b_2
1895	c_1	a_2	a_2	b_1	b_0	b_1	a_1	b_1	a_1	d_1	a_1	b_1
1896	c_0	c_2	b_3	b_1	b_1	b_2	a_1	b_1	c_1	------	a_2	a_0
1897	d_1	a_3	b_0	b_2	b_2	b_1	a_2	b_1	d_1	c_1	d_1	c_1
1898	b_1	b_2	a_0	c_1	b_2	b_0	b_0	b_1	b_1	d_1	b_1	b_1
1899	b_1	b_2	b_2	a_1	a_1	a_1	b_1	b_1	a_1	b_1	a_0	d_2
1900	c_0	b_0	a_2	a_3	b_0	b_1	a_1	a_0	d_1	b_1	b_1	b_1
1901	b_1	d_2	a_2	a_1	b_1	a_1	b_1	b_1	b_0	b_2	b_1	a_2
1902	c_1	c_0	a_2	c_1	a_1	b_1	a_2	a_1	a_1	a_1	b_1	d_1
1903	d_0	d_1	b_2	b_2	a_1	b_1	a_2	a_1	a_1	a_1	a_1	a_1
1904	b_0	b_1	b_1	b_1	b_2	b_2	d_1	d_0	a_0	b_1	b_2	a_1
1905	a_0/b_0	b_0	a_0	b_3	a_1	b_2	b_2	d_0	b_0	b_0	a_1	b_0

[1] The year runs from December to November, inclusive, thus keeping the winter months, spring months, etc., together. Hence December, 1885, for example, falls in the year 1886.

In order better to express the intensity and extent of the anomalies for the purposes of Table 2 and Figure 2, each case with index 0 (Table 1) has been given the weight of 1, each case with index 1 the weight 2, etc., and for each year the sum of all cases was obtained by adding the index number to the frequency number. Since the type B + D showed opposite distribution to the type A + C, if a negative sign be applied to the B + D type, the sum (A + C) − (B + D) becomes an expression of the mean anomaly for a given year and of the intensity of the atmospheric circulation in the region. These are given in the "difference" column of Table 2, (Table 5 in the original), the smoothed values being given in the last column, where a positive number indicates a predominance of the A + C type and thus a weakening of the circulation, and a negative number a predominance of the type B + D and an intensification of the circulation.

[6] No exact statement of the criteria on which the indices were based is given by the author.—*Ed.*

TABLE 2.—*Frequency of the types A+C and B+D, with respect to their strength and development*

Year	Type A+C		Type B+D		Difference	Smoothed values
1881	5_8	13	7_6	13	0	−4.7
1882	3_1	4	9_9	18	−14	−8.8
1883	4_6	10	8_9	17	−7	−7.2
1884	5_7	12	7_6	13	−1	+0.2
1885	8_{11}	19	4_5	9	+10	+6.8
1886	8_8	16	4_4	8	+8	+7.5
1887	8_5	13	4_5	9	+4	+6.5
1888	10_5	15	2_3	5	+10	+3.8
1889	4_2	6	8_7	15	−9	−5.2
1890	3_2	5	9_9	18	−13	−8.2
1891	6_6	12	6_4	10	+2	+1.5
1892	9_{11}	20	3_2	5	+15	+12.0
1893	11_8	19	1_2	3	+16	+8.0
1894	3_4	7	9_{13}	22	−15	−2.5
1895	6_9	15	6_5	11	+4	−1.8
1896	7_6	13	5_8	13	0	−0.5
1897	4_7	11	8_9	17	−6	−7.2
1898	2_1	3	10_{10}	20	−17	−12.0
1899	5_4	9	7_{10}	17	−8	−8.5
1900	5_6	11	7_5	12	−1	−4.2
1901	4_6	10	8_9	17	−7	−0.5
1902	9_{10}	19	3_3	6	+13	+5.8
1903	7_8	15	5_6	11	+4	+0.8
1904	2_1	3	10_{11}	21	−18	−10.8
1905	3_2	5	9_7	16	−11	−13.3

We find as periods of weakened atmospheric circulation the years

1885–1888, especially 1885 and 1888;
1891–1893, especially 1892 and 1893;
1902–1903, especially 1902;

and as periods of intensified circulation the years

1882–1884, especially 1882;
1889–1890, especially 1890;
1894;
1897–1901, especially 1894 and 1898;
1904–1905, especially 1904.

Hence, if one considers only the more significant extremes, the smoothed values show a very uniform march and a mean interval from maximum to maximum or from minimum to minimum of about eight years.

3. *Oscillations of the meridional pressure gradient between latitudes 30° and 65° north.*—Another expression for the intensity of the atmospheric circulation over the North Atlantic Ocean and a comparison with the results already given has been obtained from a study of the oscillations of the meridional pressure gradient. By deriving the monthly anomalies of meridional pressure gradient between any two parallels, and letting a positive sign indicate increase in gradient and a negative sign a diminution, we express the departures of the mean meridional pressure gradient from the normal.

From a table of these departures [not here reproduced] it is evident that extremely marked deviations occur in the several months. The extreme values are −18.9 mm. in January, 1881, and 13.2 mm. in February, 1903. The positive and negative values do not follow each other in an irregular manner, but maintain the same sign for several months and then give place to departures of opposite sign.

There appears to be no simple relation in the sequence of these periods.

In the case of the annual means of the anomalies, the alternation of type agrees exactly with the alternation of the types A + C and B + D. These annual means are expressed for the purposes of figure 2 in percentages of the normal gradient, and are shown in the second curve.

4. *West-east gradient in the far north and the meridional pressure gradient over the North Atlantic.*—Inspection of monthly anomaly charts prepared in connection with this study and of tables showing the monthly and annual anomalies of pressure gradient between the North Atlantic and Europe revealed a striking parallelism between the meridional pressure gradients and the gradient between the North Atlantic and Europe. Anomaly values were found for the east-west gradient in the region from 0° to 40° west longitude and 60° to 75° north latitude, and the graphic representation of them is presented as number 4 in Figure 2, a positive sign there indicating an increase and a negative sign a decrease in the pressure gradient.

Comparison of the curve of frequency of the type (A + C) − (B + D), or even of the meridional pressure gradient with the curve of east-west gradient, shows a

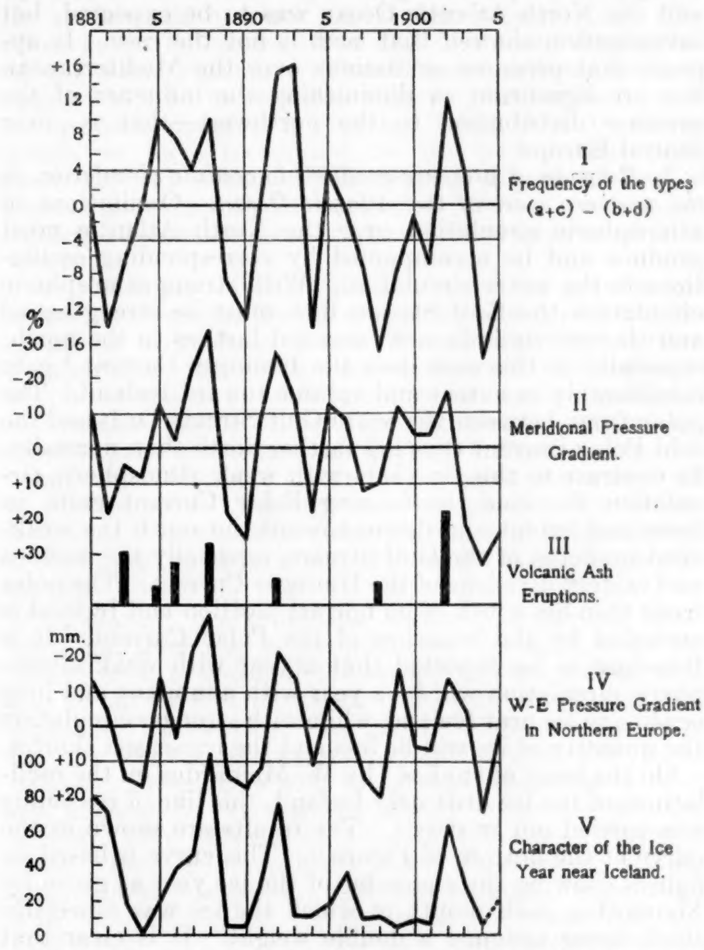


FIG. 2.—Variations in atmospheric circulation over the North Atlantic Ocean, and related phenomena

complete parallelism. Not only in the yearly means is this connection so well defined, but also when we compare the several seasons we find the same agreement. This fact can best be demonstrated by giving the correlation factors between meridional pressure gradient and the west-east gradient:

Winter	+0.76	±0.06
Spring	+0.85	±0.04
Summer	+0.59	±0.09
Autumn	+0.80	±0.05
Year	+0.762	±0.003

The connection seems to be least plainly shown in summer; in the other seasons the correlation reaches the high value of 0.8 with a probable error of 1/16 of r. The value for the yearly mean is calculated on the basis of 300 successive values, the probable error is 1/250 part of r, and the relation is thus extremely close.

Since in the formation of both the meridional and the west-east gradient there is one point in common, the close connection indicates that the anomalies are produced primarily by oscillations in pressure at the common point. This point coincides in general with the central position of the Icelandic depression. Thus it can be said that at times of weakening of this center of action there is conveyed thither for the production of the positive pressure anomaly air both from the Azores high and from northern Europe. With deepening of the depression, air masses are shifted chiefly to the south and west.

A similar shifting of air masses on the occasion of changes in the pressure gradient between central Europe and the North Atlantic Ocean was to be expected, but investigation showed that such is not the case. It appears that pressure oscillations over the Mediterranean Sea are significant in diminishing the influence of the pressure distribution to the northwest—that is, over central Europe.

5. *Relation of pressure gradient to oceanic circulation in the northern part of the Atlantic Ocean.*—Oscillations of atmospheric circulation over the North Atlantic must produce and be accompanied by corresponding oscillations in the water circulation. With strong atmospheric circulation the Gulf Stream flow must be strengthened and thereby its influence extended farther to the north; especially in this case does the Irminger Current [7] gain considerably in extent and volume toward Iceland. The polar front between the warm Gulf Stream Drift and the cold Polar Current thus lies farther north than normally. In contrast to this, in years with weak atmospheric circulation the cold, ice-bearing Polar Current gains in force and extent and drives toward the south the weakened branches of the Gulf Stream, especially the western and eastern divisions of the Irminger Current. The polar front then lies south of its normal position and Iceland is encircled by the branches of the Polar Current. It is therefore to be expected that a year with weak atmospheric circulation will be a year with abundant and long continued ice near Iceland, while with stronger circulation the quantity of ice will be less and the ice season shorter.

On the basis of studies [8] by W. Meinardus on the oscillations of the ice drift near Iceland, this line of reasoning was carried out in detail. The results are shown in the curve at the bottom of Figure 2. This curve is based on figures showing the character of the ice year as given by Meinardus, each month in which the ice was especially thick being assigned a double weight. It is clear that years with abundant ice always coincide with years having weak atmospheric circulation, and that years having little ice are years with strong circulation. The correlation factor between the meridional pressure gradient over the North Atlantic and the character of the ice year near Iceland is:

$$r \text{ equals} -0.59 \pm 0.09$$

and between the west-east gradient over northern Europe and the character of the ice year near Iceland:

$$r \text{ equals} +0.71 \pm 0.06,$$

indicating that the two phenomena are very closely related.

6. *Relation between oscillations in the strength of the North Atlantic northeast trade and the atmospheric circulation in the temperate latitudes.*—The pressure gradient from latitude 30° southward gives a measure of the force of the trade wind, which must show oscillation corresponding to those of the gradient. The monthly anomalies of pressure gradient in the region of the northeast having been determined with reference to the normal gradient for each month, it appears that in magnitude the oscillations of the gradient are considerably smaller than those of the gradients from the Azorean maximum northward, but they are just as changeable. This indicates a considerable inconstancy in the strenght of the northeast trade, and a close relation between the two sets of values. To a diminished meridional pressure gradient in the middle latitudes there corresponds in the majority of cases a diminished gradient toward the Equator in the lower latitudes. Likewise when the gradient from the Azores high northward increases, the gradient southward from it also increases. This would signify that the oscillations in the strength of the northeast trade go hand in hand with similar oscillations in the atmospheric circulation in the temperate latitudes of the North Atlantic. The closeness of this relation is shown by the correlation factors for the values of each month, as follows:

Correlation between the force of the northeast trade wind and that of the atmospheric circulation in the temperate latitudes of the North Atlantic Ocean.

December	+0.776	June	+0.506
January	+.846	July	+.582
February	+.885	August	+.662
March	+.851	September	+.622
April	+.755	October	+.696
May	+.457	November	+.651

Year, +0.777±0.105

The magnitude of the correlation factor shows a decided yearly march, being greatest in winter and least in summer, but the relation is always very well defined. The mean correlation factor, based on 300 successive monthly values with a probable error of 1/50 of the factor, indicates that the relation may be regarded as established.

Without entering upon an attempt at explanation of this striking relationship, it may merely be pointed out that it has already been implied by the fact that in the great majority of cases the pressure anomalies over the North Atlantic Ocean may be designated under the two types A and B. Stronger northeast trade wind originates especially through intensification of the Azores high, and an intensification of the Azores high in turn goes hand in hand with a deepening of the Iceland low. Thus the closed circulation of the lower latitudes is intimately connected with the circulation in the Temperate Zone.

Shaw in 1906 pointed out [9] a similar connection when, in a communication entitled "The pulse of the atmospheric circulation," he sought to bring into relation the oscillations in the intensity of the southeast trade winds in the South Atlantic with oscillations of the rainfall in southern England. The courses of the two phenomena, data on which were available for only the relatively short period 1892–1903, were surprisingly parallel. In a review of this paper, J. Hann points out [10] that perhaps the force of the northeast trade might be a more convenient guide to "feeling the pulse" of the atmosphere. Lack of suitable observational data prevented him from developing this idea further. The above results show definitely that the strength of the northeast trade is indeed such an index, and thereby probably also an index of the oceanic circulation.

[7] The Irminger Current constitutes the recurve on the northwest side of the Gulf Stream Drift south and southwest of Iceland.—*Ed.*

[8] Annalen der Hydrographie und Marit. Meteorologie, Jahrg. 1906.

[9] Shaw, W. N., The pulse of the atmospheric circulation. Nature, 21, Dec., 1905.

[10] Hann, J., Der Pulsschlag der Atmosphäre. Meteor. Zeitschr., 1906, p. 82.

In order to see further how the relation, pointed out by Shaw, between the circulation in lower and higher latitudes, appears in the now more extended data, there was calculated the correlation factor for the precipitation in England and the annual mean pressure gradient over the southern part of the North Atlantic Ocean (latitudes 30° north to 10° north). For the amount of rain over England there was taken the mean of the yearly totals in percentages of 50-year means at the five stations of Greenwich, Stonyhurst, Seathwaite, Edinburgh, and Rothesay.[11] The correlation factor resulting was r equals 0.42. It is thus relatively small, but on closer inspection of the months [table, not here reproduced] and of the individual stations it is very noticeable that in both series the extreme values fall in the same year, a fact which increases the impression of a direct relation. The combination of all the values reduced the correlation factor to the small one given, but nevertheless there appears to be a relation in the sense meant by Shaw.

7. *On the causes of oscillations in the atmospheric circulation.*—Study of the monthly pressure anomalies over the North Atlantic Ocean have shown that over these parts of the earth's surface rather significant oscillations in the atmospheric circulation take place, which, if all extremes are considered, appear to succeed each other irregularly in a period of some three to five years. A definite system in the succession does not appear to exist, while the shortness and variability of the period did not warrant the expectation that there is a relation to the rather regular changes in sunspot numbers. In the individual months, of course, there appeared to be some indication of such a relation, but on the whole a definite connection can not be affirmed. The period investigated is too short to admit of drawing a conclusion in the matter, as it includes only two sunspot periods. In this epoch the sunspot maxima occurred in the years 1884, 1894, and 1905 and the minima in 1889 and 1901.

In an exhaustive work [12] W. J. Humphreys has dealt with the question of an influence on temperature, and thereby on the general conditions of the circulation in our atmosphere, exerted by gigantic volcanic eruptions. He came to the conclusion that many, if not all, of the climatic changes on the earth have been caused by the eruption of ashes from volcanoes. Even if he seems to have gone somewhat too far in his line of reasoning—as W. Köppen has demonstrated in his paper, "Lufttemperaturen, Sonnenflecke und Vulkansausbrüche" still it appears that he was entirely correct in his belief that major eruptions of loose materials from volcanoes are a factor which is able to exert a profound influence upon the climatic conditions of our earth.

In an earlier paper [13] the writer sought to show how three factors are concerned in the determination of climatic changes, namely, solar radiation, earth radiation, and the circulation of the atmosphere. The last factor primarily takes the rôle of a regulator of meridional temperature distribution, and, due to that fact, it enters extremely intimately into the mechanics of climatic changes. Variations in the first two factors, however, are to be considered above everything else as primary causes of climatic change. If one wishes to regard oscillations of the solar constant as too small to be of climatic significance (which may not be the case, our knowledge on this point being still too limited), we have remaining as phenomena capable of affecting the temperature equilibrium of the earth's surface and of the lower layers of the atmosphere, only disturbances in the optical qualities of the earth's atmosphere. Enormous eruptions of loose material from volcanoes appear, as the most recent occurrences have forcefully shown us, to be sufficiently powerful to produce perturbations in the general circulation of the atmosphere. In such a case, as Humphreys has found, the envelope of volcanic turbidity must be 30 times as effective in obstructing solar radiation as in the repression of earth radiation. The fine, long-continuing dust veil of a volcanic ash eruption must therefore have a reversed hothouse effect, and with long continuance the resulting temperature of equilibrium of the earth would be lower than if there were no veil. The effect might be compared to that of a small diminution of the solar constant. These considerations make it appear as not improbable that in the oscillations of atmospheric circulation over the North Atlantic Ocean which we have recognized for the period 1881–1905, there are indications which support the above line of reasoning, reflecting in particular, that is to say, an influence due to the great eruptions of volcanic ash during this period.

In the study of this question, only the greater ash eruptions were considered, since only these, and not the eruptions with lava flows, are determining factors. Furthermore, the great number of small outbreaks, in which the masses of ashes and fine dust are too small and are carried to too slight a height (lower part of the troposhere), can exert no lasting influence. In the compilation of these greater eruptions, use was made of K. Sapper's "Beiträge zur Geographie der tätigen Vulkane,"[14] in which he classifies the great ash eruptions according to their intensity and to the mass of material ejected.

Tabulating the eruptions during the period 1881–1905 and assigning to eruptions of the first order the weight of 4, to those of the second order a weight of 2, and so on, we find the years 1883, 1886, 1888, and 1902 especially noteworthy. In Figure 2, below the curve for the meridional pressure gradient over the North Atlantic, these years with the greater eruptions of ashes are marked by vertical rectangles according to their weights. We observe at once that in the vicinity of those years, but especially soon after them, marked disturbances occur in the atmospheric circulation. This holds especially for the eruption years 1886 and 1888, 1892 and 1902. The fact that there is missing the year 1883, in which by the Krakatoa eruption enormous amounts of volcanic dust got into the atmosphere, is not of great significance, since in this giant eruption the dust masses were hurled far into the stratosphere, with the result that, in line with Humphreys's view, the chief effect on the atmosphere must have been shifted one or probably even two years. Indeed, we see that from 1883 to 1888 there is a continual decrease in the intensity of the atmospheric circulation, which agrees directly with the marked volcanic activity between those years. Also the years 1892 and 1902 show a diminution in atmospheric circulation. Hence it certainly does not appear to be too hazardous to assert that the major ash eruptions are accompanied by a decrease in atmospheric circulation.

Comparison of the two graphs shows us still another striking phenomenon. In the first or second years after those in which eruptions occurred and diminution in

[11] See Hellmann, G., Untersuchungen über die Schwankungen der Niederschläge. Abhandl. des preuss. meteor. Instituts, Bd. III, no. 1, 1909.

[12] Humphreys, W. J., Volcanic dust and other factors in the production of climatic changes and their possible relation to ice ages. Bulletin of Mount Weather Observatory, 6, part 1, 1903. See also Physics of the air, Part IV, chapters 3 and 4.

[13] Defant, A. Die Zirkulation der Atmosphäre in den gemässigten Breiten der Erde. Geografiska Annaler, 1921, H. 3.

[14] Zeitschr. fur Vulkanologie. 1917, Band III.

atmospheric circulation appeared, there takes place an abrupt increase in the strength of the circulation. We see this at the end of each eruption period—in the years 1889–1890 following 1888, in 1894 following 1892, and in 1903–1904 following 1902. Inspection of the individual cases showed that the conditions appeared to be not independent of the magnitude of the eruption. Before the eruption the disturbances in the general circulation are in general small, pressure gradients departing less than 2 per cent from the normal on the average. Which is to say that in general the disturbances compensate each other, since there often occur lesser decreases and increases, which are probably the remains of earlier disturbances. But in the years of eruption the circulation is greatly disturbed, and there is found first a weakening of it which even in the average of all cases is very great, since the reduction of the normal pressure gradient amounts to 10 per cent, whereas in the more marked cases it reaches, even on the average, almost 20 per cent. But the circulation soon returns to the normal intensity, and indeed we find in the year after the eruption even an intensification of it. This increase in intensity continues and in the second year reaches 7 per cent and in the more marked cases 17 per cent. Thereafter the circulation again approaches normal conditions.

Disturbances in the equilibrium of the atmosphere due to great volcanic eruptions are thus extremely characteristic. First the atmospheric turbidity caused by the eruption induces a weakening of the general circulation. This soon ceases, however, and gives place to an increase in its intensity, which, after approximately two years, varying according to the strength of the volcanic outbreak, reaches a maximum, only to decline again. It appears as if the atmospheric circulation, when thrown out of equilibrium by the disturbance resulting from volcanic eruptions, proceeds to oscillate about the position of equilibrium. The amplitudes and the periods of these oscillations depend both on the intensity of the volcanic upheaval and on the duration of the optical disturbances. After a marked weakening in circulation and after the cessation of turbidity there follows an increase in intensity, and so on.

We may develop these conditions somewhat in detail, using the consideration which are found in the earlier investigation by the author, in order to reveal the causes of the pendulum swings of the atmosphere about its position of equilibrium, swings which may appropriately be designated as "pulsations of the atmosphere." The atmospheric circulation is a current system which, with normal temperature gradient between low and high latitudes, with normal outward radiation and normal interchange of air between high and low latitudes should remain in a certain condition of equilibrium. If any one of these factors is altered, the condition of equilibrium is disturbed and the circulation now executes oscillations about its position of equilibrium, as does every other system when so disturbed. The chief cause of these pulsations is to be sought in the inertia of current conditions, since both the more constant tropical circulation and the exchange of air between lower and higher latitudes of the Temperate Zone will not suddenly adjust themselves to the modified conditions of an altered temperature gradient or to changed conditions of insolation and earth radiation, but will always lag behind these. Hence the circulation once thrown out of equilibrium varies from it now in one direction, now in another. It will be now stronger, now weaker, and these "beats" will gradually diminish in force. The damped oscillations about the position of rest must follow a period which is determined by the structure of the atmospheric circulation and the dimensions of the earth. In other words, we have here to deal with a phenomenon which is similar to the free oscillation of a system, and these pulsations of definite period can be designated as such.

Let us consider one such case more closely. The atmosphere and its circulation are at first in normal condition. By a great volcanic eruption the temperature in the lower latitudes is considerably lowered. Thereby the meridional temperature gradient is automatically decreased, with the result that the closed circulation in the Tropics and subtropics and the exchange of air in higher latitudes undergoes a weakening. This weakening will proceed of itself at first as the result of movement once initiated. Later, due to lessened exchange between lower and higher latitudes, it will cause an increase in meridional temperature gradient, extending farther and farther because of the gradual fading of the turbidity, and causing an intensification of the circulation. After this again a weakening in the temperature gradient takes place and correspondingly a weakening in the strength of the circulation. So, after a given interval subsequent to an original weakening of the circulation, there follows an intensification and after this a weakening, and so on.

The period of these damped and subsiding pulsations should be obtainable in a purely theoretical manner, the equations from which one must proceed being given in the author's paper cited above. The mathematical difficulties which beset the solution of this problem may of course be considerable. It appears, however, that this fundamental period may be obtained from observations. The years 1883–1888 were characterized by great eruptions, but in this interval the period can not well reach complete development, since one turbidity in part overlaps another and there is disturbance in the evolution of the resulting phenomena. But after this time until 1902 very marked eruptions took place only in 1892 and 1898, and the phenomena resulting from the great eruption period 1883–1888 could develop almost undisturbed. The second curve of Figure 2 shows that in this period maximum follows minimum almost regularly, so that the mean period calculated from both maxima and minima amounts to 3.5 years, which is, therefore, probably the natural period of the pulsations of the atmospheric circulation. The circulation when once thrown out of equilibrium swings back and forth and thereby causes long-period climatic changes. The pulsations become gradually extinguished, however, as the case after 1888 shows, since the amplitude of the oscillations becomes smaller from swing to swing.

Only when a new disturbance, a new and mighty eruption, takes place, do the pulsations attain a greater amplitude. It is then a matter as to the point of time at which, in the fading pulsations of an earlier disturbance, the new one takes place whether the vibrations are now to proceed reinforced in the same phase, or, on the contrary, with a shift in phase. In the year 1892 the eruption takes place in a year of weakened circulation and the new disturbance is in the same phase as the earlier pulsations. In 1898, on the other hand, the eruption, only a weak one, to be sure, appears not to have been in the same phase, hence the period of marked disturbance, in 1902 is the first to bring a revival of the pulsations with suddenly increasing amplitudes.

It is extraordinarily striking that the same period of 3.5 years, which we have here designated as the natural period of the atmospheric circulation when its equi-

librium is disturbed, has, it would seem, a very general character. This has been demonstrated unequivocally in the work of the Solar Physics Committee, "Mean monthly values of barometric pressure," by N. Lockyer.[15] C. Braak has investigated [16] this in detail for the Dutch East Indies and has shown that it is reflected in both the temperature and the pressure conditions as well as in precipitation, and that the periodic changes in the north-south gradients between Australia and the East Indies are the "faithful companions" of these pulsations.

It is not improbable that in this approximate 3.5 year period in the pulsations of the atmospheric circulation we are dealing with a phenomenon of extreme importance in the weather sequences of the longer periods of time.

[15] Lockyer, N., Solar Physics Laboratory, South Kensington, 1908.
[16] Braak, C., Periodische Klimaschwankungen, Meteor, Zeitschr., 1910, pp. 121-124. Die 3.5-jährige Barometerperiode, Meteor. Zeitschr., 1912, pp. 1-7.

TORNADO NEAR FITCHBURG, MASS., JULY 17, 1924 [17]

By Charles F. Brooks

(Clark University, Worcester, Mass., July 19, 1924)

About noon, July 17, 1924, with the arrival of the thundersquall on a marked wind-shift line, a tornado hit here and there along a path about 18 miles long from near Templeton, through Gardner, Westminster, southern Fitchburg, and Whalom, Mass. This course, averaging from west by south, when projected toward the east-northeast, passes near Lowell, Lawrence, Haverhill, and Newburyport, where torrential rain occurred shortly after. Here and there along the path there were groves of trees destroyed, factories nearly demolished, roofs and upper stories blown off, and chimneys generally blown down. So localized was the damage, however, that little was to be observed, for example, from the main thoroughfare from Leominster to Fitchburg across the storm path. Two were killed, and damage estimated at $500,000 to $1,000,000 was done, according to the Worcester Telegram.

While the local severity of the damage and the generally narrow and direct path in which destruction occurred, would lead one to suspect the action of a tornado, eye observation of the funnel cloud by Leroy Moreland and others at and near Whalom, and the criss-cross fall of forest trees there leave no doubt as to the whirling nature of the wind. With a geological compass I climbed over the fallen trees at Whalom, and obtained their direction of fall. Most were blown down from a west southwesterly direction, but near the northern edge of the zone of destruction, where the funnel cloud had been seen the trees were blown down from south and north as well as from west. A barn that was hit, blew down northwards, the north wall being blown out lower end first, and boards being carried a few tens of feet clear of the general wreckage.

A few details will be appropriate. After blowing down or partly wrecking some factories and tenements in the southern part of Fitchburg, the storm for the next 2 miles before reaching Whalom broke off or uprooted many large trees, blew down chimneys and damaged some roofs. A ball park fence was partly blown down, a tent carnival blown away, and a small grove of pines demolished, the trees generally being broken off half way up. Approaching Whalom, a large elm, well rooted, but exposed on a hill, was blown down from the southwest. The tree was about 3½ feet in diameter, and was said to have been growing there for at least 168 years. The upturned roots reached to a height of nearly 20 feet. A number of other trees were uprooted or blown down in this vicinity. A local resident said that another member of the family had seen a funnel cloud. At Whalom Park about half the trees (mostly pines 1 to 1½ feet in diameter) were blown down by uprooting or breaking. They lay mostly from southwest by west (compass bearing W.20–30° S.), though a few lay on top from about west northwest (compass W. 30° N.). This was one-half to three-quarters mile south of the path of the funnel center. Across the road from Whalom Park, in a grove one-quarter to one-half mile from the path, about two-thirds of the trees were blown down. These were larger than those in Whalom Park, ranging up to 2 feet in diameter. About as many were broken off as uprooted. They were blown down from the same directions as those in Whalom Park, though there were more from the west northwest, perhaps a quarter of the total, as compared with only a few in Whalom Park.

A little farther north, at Sunnyside Farm, I came upon the region within the path of the funnel cloud. In describing the storm, Mr. Leroy Moreland, who with his father manages the farm, said he was between the two barns that were not blown down (the more southerly of three) when he saw what he thought at first was the smoke from a bad fire in the woods westnorthwest of him. There was a ragged cloud mass, whirling violently, coming straight towards him. It appeared white. It seemed to be bouncing up and down somewhat as it approached. Suddenly it turned at about a right angle just in time to avoid all but one of the barns. He had never before seen a cloud anything like that. The noise was terrific. Unfortunately for further observation of the storm, Mr. Moreland had to take shelter. He said the tornado struck at 12:20 or 12:25 p. m. (At Fitchburg, 2⅓ miles away the time of the storm was reported as 12:15.) Another man at the same farm said he saw a whirling cloud approaching, and that it had become extraordinarily dark. Others, at Whalom Park, had not seen the tornado cloud. Anyway, trees would have prevented their viewing it. One man with whom I talked said he had seen a small funnel cloud at Manchester, N.H., at about the time of the storm here.

The mixed forest through which Mr. Moreland had seen the funnel cloud come was about half destroyed, an open gap being cut about 50 feet wide from the west-northwest where the center passed. South of this gap some individual trees and clumps were blown down from the southsoutheast (compass bearing S. 5° E.), and a few from the southwest, but the great majority lay from between west by south and westnorthwest (compass W. to W. 30° N.). North of the gap about half the large and small oaks, maples, birches, etc., were down, mostly from the westnorthwest (compass W. 30° N.). There were several, however, from the northnorthwest (compass bearing N. 10° W.) under those from more westerly directions. From 250 to 300 yards beyond this was the barn that was blown down at about the place where the funnel cloud turned. About 50 yards south of this barn a silo had gone down and the corner of a barn roof had been blown off, while a few yards farther all seven chimneys of the well-built farmhouse had been blown

[17] This is but a brief account. Clippings from the local press of important places affected, of nearby cities, and also a few photographs are on file at the U. S. Weather Bureau office, Boston, Mass. This published report is based on a brief tour of observation through the region of greatest damage near Fitchburg, and on some of the newspaper accounts for other portions of the path of the heavy storm.

flat. Just east to northeast of the barn that was blown down a young apple orchard had every tree in it uprooted, broken or bent from a southwesterly direction.

Although there was no complete destruction even in the direct path of the funnel cloud, the wide extent of considerable destruction, at Whalom upwards of three-fourths of a mile, was a notable feature of this storm.

The occurrence of severe winds and partial destruction by such winds here and there was reported, while the greatest damage farther on occurred in the Merrimac Valley from a cloudburst. The downpour began at Lawrence at 12:45 p. m. (60th mer. time), and the darkness was extreme. This rain flooded and severely washed out a number of streets, and added to the damage of the hail in an immediately preceding storm.

In connection with the strong winds, presumably in one of the storms on this date a barrel was picked up, carried half a mile and deposited on top of a tall pole at Rye Beach, N. H. Such is the statement in the Worcester Evening Post, for July 29, under a photograph of the barrel in this position.

THE GREAT HAILSTORM IN SOUTHEASTERN NEW HAMPSHIRE AND NORTHEASTERN MASSACHUSETTS, JULY 17, 1924

By B. M. VARNEY

(Weather Bureau, Washington, August 26, 1924)

The advance of the wind-shift line eastward from the region of tornado damage described in the previous article continued to be accompanied by violent convectional overturning, which caused severe thunderstorms, with falls of hail at Lawrence, Mass., said by old residents to be more remarkable than a great fall which occurred there on July 4, 1880. Following the hailstorm after an interval of about an hour, another thunderstorm added a rainfall of almost cloudburst intensity. The total precipitation recorded at Lawrence was 1.29 inches.

Press reports indicate that the severest disturbance (which was of tornado violence only in the area noted in the foregoing account) moved about east-northeast over a belt of country some 15 miles wide and lying largely north of the Merrimack River, which in this part of its course flows also about east-northeast. The southernmost damage reported by the press occurred in Andover, south of the river, and the northernmost in Salem, N. H. That the heaviest disturbance passed off the New England coast between Newburyport, Mass., and Portsmouth, N. H., is shown by the accounts of torrential rains and high winds at the former place, and of the depositing of the barrel on a telegraph pole at Rye Beach, N. H., as noted by Dr. Brooks. There are no reports of extraordinary conditions at Portsmouth. The movement thus indicated corresponds somewhat closely in direction with that of the center of the controlling cyclone, as nearly as that can be determined from the weather maps. At Blue Hill Observatory (640 ft. altitude) a maximum wind velocity of 72 miles per hour was recorded during the passage of the squall line.

On the maps herewith are shown the pressure distributions concerned, for 8 a. m. and 8 p. m., 75th meridian time, July 17, 1924. Arrows show the observed wind at selected stations (the initial letters of which are shown), the broken lines show the approximate positions of the wind-shift line, and the symbol of parallel lines on the 8 p. m. map the position of the belt (as well as it can be located from published reports) within which occurred the hail storm and the rainstorm here referred to and the tornado and high winds discussed in the foregoing paper.

The disturbance as reported from Lawrence and vicinity consisted of two distinct parts, as will be noted in the following quotation from the Lawrence Telegram of July 17, 1924: "Two of the most spectacular and unusual freak summer storms in the history of Lawrence visited the city within the short space of two hours Thursday and did damage that will run into the thousands of dollars.

"Nature sent a thunder and lightning storm about 11 o'clock calculated to strike terror into the stoutest of hearts, when darkening skies, roaring thunder, flashing lightning, and sweeping rains were followed by a shower of hailstones varying from countless lumps of ice the size of marbles to thousands of larger ones as big as hen's eggs.

"The hailstorm in itself was thrill enough for one day, but the elements were not finished. At 12.45 a darkness as of night descended over the city, the thunder rumbled, the lightning flashed, and in a twinkling Lawrence was deluged in a fall of rain that was a veritable cloudburst. The rain swept down upon the darkened city in torrential sheets flooding the streets, overrunning the sidewalks and completely exceeding the capacity of the city sewers.

"The hailstorm was the most severe and unusual within the memory of the oldest resident of the city and the city underwent a veritable bombardment of icy pellets. Up to press time nobody had been reported injured, but that was nothing more or less than a miracle, because most of the icy stones falling were of a size sufficient to stun and injure anyone struck by them. To talk of hailstones as large as hen's eggs may seem like exaggeration to those who were not in the city during the storm, but thousands of local residents present can truthfully testify that they were the rule rather than the exception, while the sizes in odd cases ran to almost unbelievable extremes. [In Methuen and Salem counties lumps of ice larger than baseballs are reported to have fallen.—Ed.]. The Lawrence Common and lawns all over the city were covered after the storm with thousands of hailstones of all sizes.

"The places in this vicinity which suffered the worst were Salem, N. H., and Methuen, in the opinion of those who visited the different localities after the storm. North Andover and Boxford were hit hard also, but very little damage was caused in Lawrence or Andover except in isolated cases. The storm, which came from the north, cut a wide swath through Salem and Methuen. According to observers the storm struck Salem with all its force and then moved southward, striking the western section of Methuen, where it veered eastward and moved in the direction of Pleasant Valley across the northern and central section of the town. Near Pleasant Valley it swerved to the south across the Merrimack river, struck North Andover and Boxford and continued on toward Haverhill following the course of the river. Only the edge of the storm vortex [?] was felt in Lawrence and consequently the damage was not as heavy as in Methuen and Salem which felt the full force of the gale and the accompanying hailstones.

"An exact estimate of the damage caused by the storm is impossible because of the wide area affected and because in some localities the damage was so widespread that it

would be impossible to reach a fair estimate of it. In Salem, N. H., the crops and fruit trees on almost every farm were destroyed and one Salem farmer stated that the farms in his vicinity were practically ruined. Innumerable fruit trees were shorn of their budding fruit, corn and other crops were levelled to the ground, market gardens were riddled by the hail and hundreds of windows in farmhouses and barns were broken.

phone lines were reported out of commission, an estimated total damage of $15,000 occurred to four greenhouses (none of them insured and one of them, under construction, just nearing completion), while in a school building nearly all the window panes on the north side on two floors were broken.

The total damage from the hailstorm in Lawrence, Methuen, and Salem is placed at $75,000. Of this, some

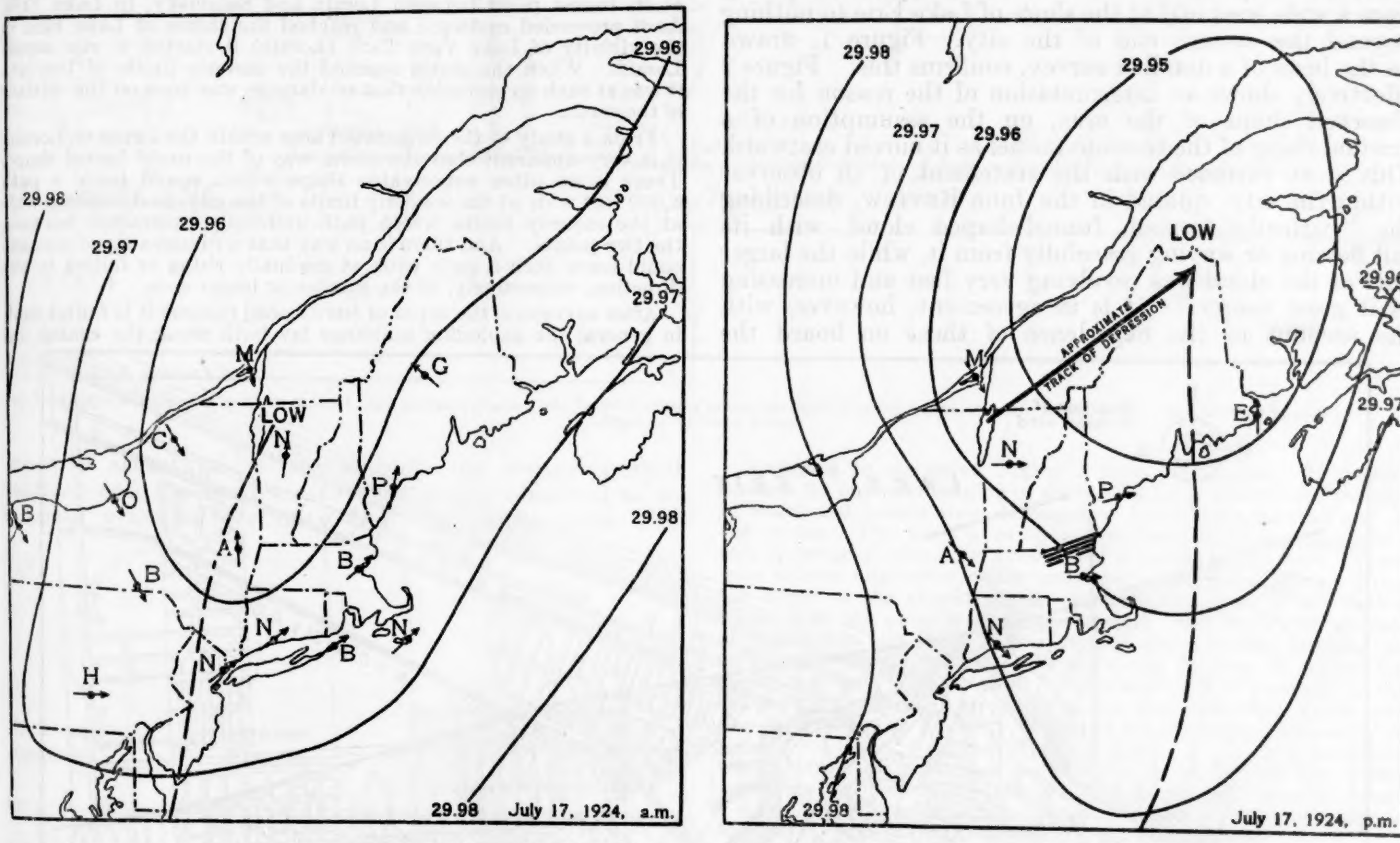


Fig. 1.—Pressures, wind directions and approximate positions of the wind shift line over New England at 8 a. m. and 8 p. m., July 17, 1924. The parallel lines on the 8 p. m. map in southeastern New Hampshire and northeastern Massachusetts show approximately the area within which occurred the damage noted in this and the preceding article

"In Boxford and North Andover the storm caused more damage than in Lawrence. The crops on many farms were riddled and leveled to the ground by the large hailstones, and fruit trees were ruined. The damage to crops and trees is estimated at several thousand dollars."

Though Lawrence appears to have suffered less from the hailstorm than the surrounding country, 500 tele-

$50,000 is assigned to destroyed crops, including extensive injury to fruit on trees. Expense of remaking street grades, of which many on the hillier parts of Lawrence were badly washed out during the second storm, and of restoring storm sewers to working order, will add some thousands of dollars to the above sum.

WINDSTORMS IN WISCONSIN, AUGUST 7, 1924

By W. P. Stewart

[Weather Bureau, Milwaukee, Wis., Sept. 10, 1924]

Two tornadoes which formed almost simultaneously in west-central Wisconsin during the evening of August 7, 1924, caused seven fatalities and a property loss estimated at about $300,000.

The first of these storms appeared in the vicinity of Osseo, Trempealeau County, about 6:30 p. m., moving from northwest to southeast. It was last reported near Black River Falls, Jackson County, about 27 miles southeast, half an hour later. The funnel-shaped cloud was seen by all observers. The width of the path of great destruction was variously estimated as from 1,000 feet to a mile. Four persons were killed, and many were more or less seriously injured. A few dwelling houses and a large number of farm buildings were destroyed.

The second tornado originated apparently a few miles northwest of New Auburn, Chippewa County, probably just north of the Barron County line. It moved from northwest to southeast and was first reported at 7:00 p. m. The funnel-shaped cloud was seen by many observers. The width of the path of great destruction was about 60 rods, and the length 8 to 10 miles. Three persons lost their lives and approximately 100 were injured. Several farm residences and a large number of other farm buildings were destroyed. The loss of crops from both of these tornadoes was heavy. It is not practicable to estimate the speed with which these storms moved, as the time is not reported with sufficient accuracy.

A FURTHER NOTE ON THE LORAIN, OHIO, TORNADO OF JUNE 28

By B. M. VARNEY

[Weather Bureau, Washington, Sept. 11, 1924]

Supplementing the account of the Lorain tornado published in the June REVIEW, we are able, through the courtesy of the *Engineering News-Record*, to reproduce the diagrams [18] herewith.

Previous report describes the area damaged as tapering from a wide west end at the shore of Lake Erie to nothing beyond the eastern end of the city. Figure 1, drawn on the basis of a detailed survey, confirms this. Figure 2 effectively shows an interpretation of the reason for the observed shape of the area, on the assumption of a gradual rising of the tornado funnel as it moved eastward. This is at variance with the statement of an observer within the city, quoted in the June REVIEW, describing the "perfectly formed, funnel-shaped cloud, with its tail flowing or waving gracefully from it, while the larger part of the cloud was revolving very fast and increasing as it grew nearer." It is in agreement, however, with the account of the experience of those on board the yacht observations, in the *Engineering News-Record*, as follows:

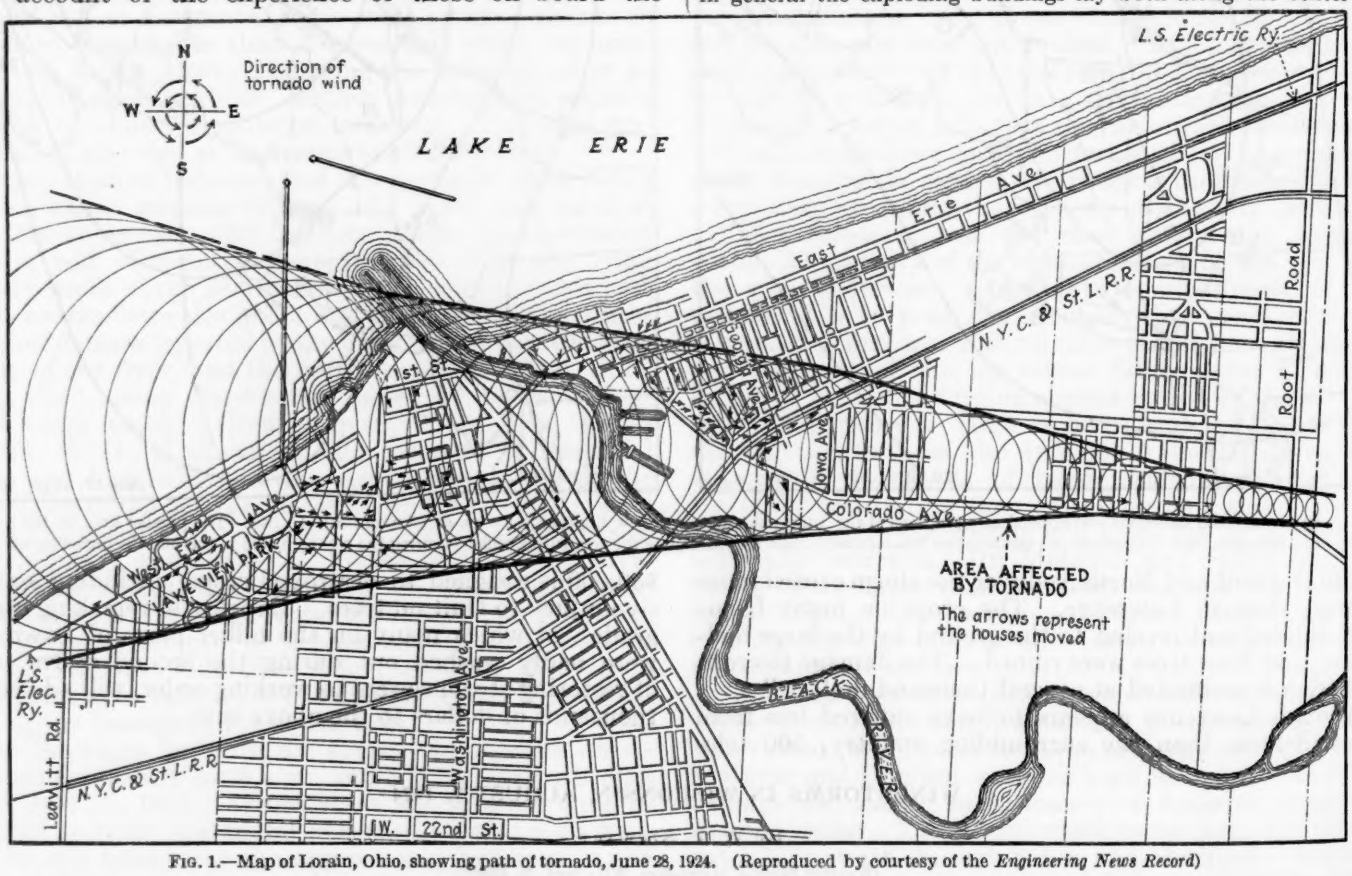


FIG. 1.—Map of Lorain, Ohio, showing path of tornado, June 28, 1924. (Reproduced by courtesy of the *Engineering News Record*)

Oswichee, who "saw a very black cloud estimated at one-half mile wide at the water and much wider at the top." The *Oswichee* became involved in the storm about 7 miles west of Lorain. The zone of damage where the cloud came on shore is reported in the *Engineering News-Record* as being some 6,000 feet wide. Though tornadoes frequently display an extraordinary hop-and-skip motion as they progress, it seems unlikely that in 7 miles the form of this tornado would change from that of a truncated inverted cone "about one-half mile wide at the water," to a funnel "with its tail flowing," and back again to the truncated cone 6,000 feet wide at the ground. It is possible that the observer first quoted saw a whirl secondary to the main cloud.

Mr. C. C. Miller, city engineer of Lorain, gives his version of the occurrence, with conclusions from his

> The storm has been traced from Sandusky, about 30 miles west of Lorain, to Avon village, about 20 miles east of Lorain. After the storm had reached Sandusky it apparently descended and was at its lowest point between Lorain and Sandusky, in Lake Erie. As it proceeded eastward and reached the shores of Lake Erie in the vicinity of Lake View Park (Lorain) it started to rise across Lorain. When the storm reached the easterly limits of the city it was at such an elevation that no damage was done on the surface of the earth.
>
> From a study of the devastated area within the limits of Lorain, it is very apparent that the storm was of the usual funnel shape. There is no other conceivable shape which would leave a path 6,000 feet wide at the westerly limits of the city, and 500 feet wide at the easterly limits, which path uniformly contracted between the two points. And there is no way that a funnel-shaped tornado could leave such a path without gradually rising or falling in the direction, respectively, of the smaller or larger area. * * *
>
> After surveying the types of [structural] failures it is found that, in general the exploding buildings lay both along the center line of the storm and along the outer edges. This would seem to indicate a [partial] vacuum extending through the the center of the whirling mass of air and one immediately outside of the whirling mass.
>
> It will be noted in Figure 1 that the houses in the westerly section of the city were moved practically all in the same direction. This is due to the larger diameter of the storm at this point. On the easterly side of the city, where the diameter was small, the tail of the tornado alone was the effective part. Here the buildings were moved in nearly every direction.
>
> The proof that the storm was a whirling mass of air is shown by the fact that furniture and smaller buildings were first thrown to the north and immediately houses and buildings were demolished by a stronger wind coming from the north. The wind when moving in the same direction as the storm was very much more intense than when the wind traveled in a direction opposite to that of the storm.

[18] Eng. News-Record, 93, no. 5, July 31, 1924, pp. 190-191.

The item of greatest interest in the above quotation is that regarding the possibility of a partial vacuum existing in connection with the periphery of the whirl, and the suggestion that it may be sufficiently low to cause explosive effects. In reply to a query as to whether the identical, Mr. Miller offers the comment below, with Figure 3 in illustration of it. The possibility that such a condition may accompany tornadoes has, it is believed, not hitherto been suggested, and is therefore presented for the consideration of our readers:

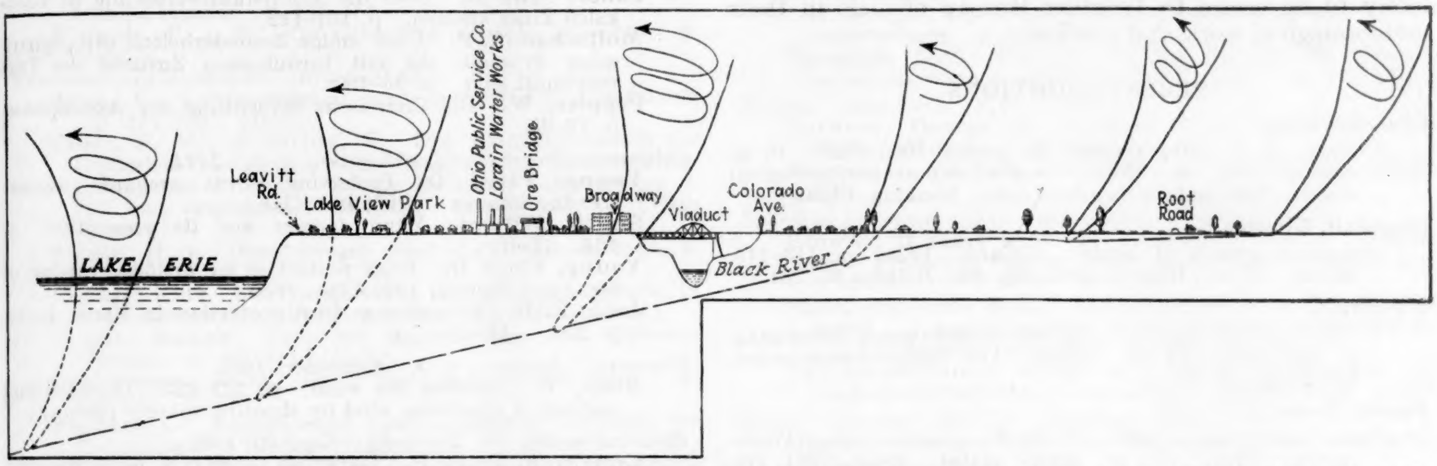


FIG. 2.—Diagrammatic cross sections of the Lorain tornado, showing relation of decreasing area at the earth's surface to the rise of the funnel cloud. (Reproduced by courtesy of the *Engineering News Record*)

types of structural failure in both the central partial vacuum and the border area were so far identical as to indicate practical certainty that the causes were also

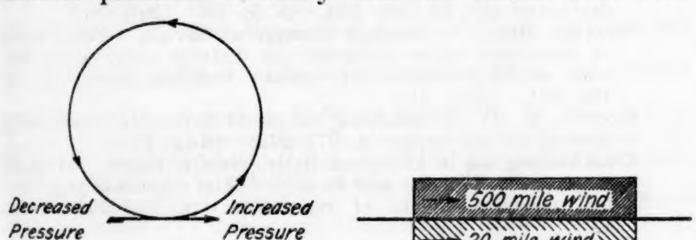


FIG. 3.—Conditions of wind and pressure in relation to the suggested partial vacuum at edge of tornado. (C. C. Miller)

Referring to the print, Figure A [not reproduced. It depicts damage by outward bulging of walls.—B. M. V.] shows the method in which the houses were damaged on the outer edge and also in the center. The walls were bulged outward or blown completely out, showing of course the presence of a vacuum. * * * There were a large number of houses damaged in the same manner along the edges of the storm's path. It does not seem to me that a vacuum at the outer edge of the storm's path would be unusual or impossible. If there is a condition which would produce an increased pressure, there would also exist an area in which the pressure would be decreased. The cause of the vacuum in the center of the storm is of course due to the centrifugal force, and the outer vacuum, I believe, is due to the difference in velocity of the two volumes of wind. Figure 3 shows * * * a condition which would be favorable for a vacuum along the line which separates the two winds traveling at a different rate of speed. I would believe that if a vacuum really exists on the outer edge of the storm, that it would necessarily be very narrow.

NOTES, ABSTRACTS, AND REVIEWS

SOLAR AND TERRESTRIAL RADIATION [19]

By A. ÅNGSTRÖM

(Reprinted from Science Abstracts, Aug. 25, 1924, § 2023)

Continuous records of the total radiation received from the sun and sky have been obtained at Stockholm since July, 1922. From these the annual and daily variation of the radiation received may be obtained, and as the direct solar radiation may be computed from the time of sunshine, the variation, both of the direct and the diffused radiation, is known. The total amount of radiation received during the day, Q_s, may be expressed in the form: $Q_s = Q_0\,(0.25 + 0.75S)$, if Q_0 is the amount on a perfectly clear day, and S is the time of sunshine expressed as a fraction of the greatest possible time. The total radiation received is a minimum in the afternoon of days when the sky is less than half-covered with cloud, and a maximum in the afternoon of overcast, or nearly overcast, days; this is due to the operation of convection.

The nocturnal radiation has been measured at stations where the temperature ranged from −30° C. to +30° C. The results obtained show that the radiation from a black surface at a temperature between these limits may be divided into three groups of waves: (1) About 25 per cent of the radiation passes through the atmosphere without absorption, and is independent of the thickness of the atmosphere and the amount of water vapor it contains; (2) about 50 per cent is totally absorbed by a thin layer of the atmosphere, probably in the lowest 30 meters at ordinary vapor pressures; (3) about 25 per cent is subjected to a variable absorption, depending chiefly on the amount of water vapor present.—*A. W. L.*

[19] Roy. Met'l Soc. Jour., April, 1924, 50: 121-126. Report to the International Commission for Solar Research on Actinometric Investigations of Solar and Atmospheric Radiation.

BIBLIOGRAPHY

C. FITZHUGH TALMAN, Meteorologist in Charge of Library

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

RECENT ADDITIONS

Chu, Coching.
Climate of Nanking during the period 1905–1921. 16 p. charts. 26½ cm. (Repr.: Annual report meteorological station, National southeastern univ., Nanking, China.)

Crandall, Charles S.
Blooming periods of apples. Urbana. 1924. p. 113–145. 23 cm. (Univ. Illinois, agric. exp. sta., Bulletin no. 251.)

Knoch, K.
G. Hellmann als Forscher. Zu seinem siebzigsten Geburtstag. p. 537–543. 27½ cm. (Extr.: Die Naturwissenschaften. 12. Jahrg., H. 27.)

Perret, Frank A.
Vesuvius eruption of 1906. Study of a volcanic cycle. Washington. 1924. 151 p. illus. plates. front. 30½ cm. [Carnegie institution of Washington. Publication 339.]

Pickering, William H.
Lunar atmosphere. 4 p. 26 cm. (Extr.: Pop. astron., v. 32, no. 5, May, 1924.)

Simpson, George C.
British antarctic expedition 1910–1913. Meteorology. v. 3. Tables. London. 1923. xi, 835 p. 31½ cm.
Water in the atmosphere. 16 p. 21½ cm. (Royal inst. Great Britain. Weekly evening meeting. March 2, 1923.)

Szymkiewicz, Dezydery.
Études climatologiques. Warszawa. 1923. no. 4. 22 p. 24½ cm. (Acta soc. bot. Poloniae. v. 2, nr. 2, 1924.)

Wayman, John H.
Earth's weather; or, Meteorology. Pittsburgh. c1924. 152 p. illus. charts. 23½ cm.

RECENT PAPERS BEARING ON METEOROLGY AND SEISMOLOGY

The following titles have been selected from the contents of the periodicals and serials recently received in the library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

Akademie der Wissenschaften. Sitzungsberichte. Wien. Abt. IIa. Bd. 132, H. 3 & 4. 1923.
Defant, Albert. Theoretische Überlegungen und experimentelle Untersuchungen zum Aufbau hoher Zyklonen und Antizyklonen. p. 81–103.

Annalen der Hydrographie und maritimen Meteorologie. Berlin. 52. Jahrgang. Mai 1924.
Benkendorff, Rudolf. Der Nachrichtendienst im Rahmen des Wetterdienstes der Deutschen Seewarte. p. 97–102.
Benkendorff, Rudolf. Organization und Arbeiten des Wetterdienstes der Deutschen Seewarte für Schiffahrt und Fischerei. p. 102–107.
Danmeyer, F. Über relative Sichtmessung durch Stufen- und Keilfilter. p. 108–113.
Exner, Felix M. Traveling cyclones von V. H. Ryd. p. 113–115.

Annales de géographie. Paris. 32 année. 15 juillet 1924.
Eredia, Filippo. Le climat de la Tripolitaine. p. 392–395.
Maurain, Ch. Alfred Angot (1848–1924). p. 396–397. [Obituary.]

Astronomie. Paris. 38 année. Juin 1924.
Flammarion, Camille. Le minimum actuel des taches solaires, la pluviosité et les intempéries. p. 242–248.

Beiträge zur Physik der freien Atmosphäre. München. Bd. 11. H. 3. 26. März 1924.
Exner, Felix M. Über die Temperaturverteilung in vertikalen Zirkulationen. p. 101–112.
Moltschanoff, P. Über einige Besonderheiten atmosphärischer Prozesse, die mit turbulentem Zustand der Luft verknüpft sind. p. 96–100.
Peppler, W. Die thermische Schichtung der Atmosphäre. p. 79–95.

California citrograph. Los Angeles. v. 9. 1924.
Young, Floyd D. Protecting citrus orchards against freezing damage. p. 96; 98. (Jan.)
Smith, Willard. Wind damage and its prevention. p. 124. (Feb.)
Young, Floyd D. Frost protection by artificial mixing of air. p. 125; 132; 136; 138. (Feb.)
Jones E. H. Irrigation as frost protection in citrus grove. p. 260. (May.)

Discovery. London. v. 5. September, 1924.
Riley, T. Shooting the wind. p. 222–223. [Richardson's method of observing wind by shooting spheres upward.]

Electrical world. N. Y. v. 84. Sept. 20, 1924.
Creighton, E. E. F. Lightning protection from Franklin through Faraday to the aluminum electrolytic arrester—Difficulty of the problem and illusive nature of many discoveries that were apparently successful. p. 622–623.

Engineering news-record. N. Y. v. 93. 1924.
Ohio tornado destroys Lorain business district. Theater wrecked by falling débris—about 1,000 dwellings and stores destroyed and 65 lives lost. p. 54–56. (July 10.)
Further notes on tornado damage at Lorain, Ohio. Little of structural value adduced—no definite conclusions possible as to resistance of various building materials. p. 190–191. (July 31.)
Brown, R. T. Minimizing danger of dynamite blasts being ignited by lightning. p. 271–272. (Aug. 14.)
Combating ice in European hydro-electric plant. Methods employed in Norway and Sweden—chief sources of trouble—ice pressure—effects of regulation. p. 265–266. (Aug. 14.)

Forecast. Philadelphia. v. 28. September, 1924.
Theiss, Lewis Edwin. A modern oracle—the weather man. p. 163–165; 185; 194.

France. Académie des sciences. Comptes rendus. Paris. t. 178. 10 juin 1924.
Nodon, Albert. Observations sur la propagation des ondes explosives lors des expériences de La Courtine. p. 1993–1995.

Geographical journal. London. v. 64. July 1924.
Brunt, David. Climatic continentality and oceanity. p. 43–56.

Hemel en dampkring. Den Haag. 22 Jaarg. 1924.
Pinkof, M. Overzicht van de halo-waarnemingen te Amsterdam in 1923. p. 253–259. (Augustus.)
Monné, A. J. Neerslag te Nijkerk 1889–1923. p. 275–281. (September.)
Pinkhof, M. Het meteorologische station in den Amsterdamschen Hortus. p. 265–275. (September.)

Italy. Commissariato dell' aeronautica. Rendiconti tecnici. Anon 12. 15 maggio 1924.
Matteuzzi, Luigi. Teoria matematica delle oscillazioni barometriche e previsione scientifica del tempo. p. 8–18.

Japanese journal of astronomy and geophysics. Transactions and abstracts. Tokyo. v. 1. no. 7. 1924.
Kobayasi, Tatuo. On the mechanism of cyclones and anticyclones. p. 219–236.

Journal of scientific instruments. London. v. 1. August, 1924.
Laby, T. H. A standard barometer of new design. p. 342–345.

Meteorologia pratica. Montecassino. Anno 5. Maggio-giugno 1924.
Crestani, G. Le trombe nel Friuli. p. 90–93.
Cuomo, Vincenzo. Meteorologia e salute umana; Importanza degli studi di fisio-patologia meteorica e loro applicazioni medico igieniche. p. 84–89.
Oddone, Emilio. Teoria della oscillazone semidiurna di pressione. p. 77–83.
Valbusa, U. Chiusura ermetica per aste mobili di anemografi. p. 94–97.

Meteorological magazine. London. v. 59. August 1924.
Bilham, E. G. The thunderstorm of July 22nd, 1924. p. 152–155.
Brooks, C. E. P. The question of the permanence of cyclone tracks. p. 156–158.
Frank Hagar Bigelow. p. 167. [Obituary.]
Harwood, W. A. The boundary between calms and neighbouring breezes. p. 160–161.
Whipple, F. J. W. On rainfall of very rare intensity. p. 149–152.

Meteorologische Zeitschrift. Braunschweig. Bd. 41. 1924.
Baur, F. Luftfeuchtigkeit und menschliche Ausatmung. p. 224–225. (Juli.)
Exner, F. M., & Süring, R. Der Ehrenvorsitzende der Deutschen Meteorologischen Gesellschaft; Geheimer Regierungstrat Prof. Dr. Gustav Hellmann vollendet am 3. Juli sein siebzigstes Lebensjahr. p. 197. (Juli.) [With portrait.]
Ficker, H. v. Bemerkungen über die Äquatorialfront. p. 202–206. (Juli.)
Fischer, Karl. Die Verdunstung des Weserquellgebiets, in methodischer Hinsicht betrachtet. p. 211–216. (Juli.)
Geiger, Rudolf. Über die Registrierung von Kälteeinbrüchen. p. 207–211. (Juli.)
Groissmayr, Fritz. Der "thermische Relativwert." p. 222–223. (Juli.)
Kassner, C. Bemerkungen zum Angotschen Verfahren der Reduktion von Niederschlagsmitteln. p. 220–222. (Juli.)
Kassner, C. Über die Dauer des sommerlichen Frühregens. p. 219–220. (Juli.)
Pollak, Leo Wenzel. Verwandlung von Registrierinstrumenten in Kontrollapparate. p. 225–226. (Juli.)
Schmauss, A. Korrelationen von März: September. 1. p. 198–202. (Juli.)
Schmidt, Wilhelm. Anders Angström, Studien zum Frostproblem. III. p. 223–224. (Juli.)
Stüve, G. Zur Frage der Äquatorialfront. p. 206–207. (Juli.)
Wigand, Albert. Ein Mattkeil-Sichtmesser. p. 216–219. (Juli.)
Dorno, C., Meissner, K. W., & Vahle, W. Zur Technik der Sonnenstrahlmessungen in einzelnen Spektralbezirken (Filterdurchlässigkeit, Zellenempfindlichkeit, Michelson-Aktinometer). p. 234–239. (Aug.)
Fischer, Karl. Der Sinn der Gleichung Niederschlag = Abfluss + Verdunstung + Versickerung. p. 244–246. (Aug.)
Grosse. Böigkeitsmessungen. p. 249–250. (Aug.)
Kotschin, N. Bemerkungen zur Theorie der Polarfront. p. 251–252. (Aug.)
Myrbach, Otto. Temperaturjahr und Kalenderjahr. p. 256–257. (Aug.)
Peppler, W. Bemerkungen zum Bjerknesschen Schema der Kälte- und Warmefront. p. 250–251. (Aug.)
Röstad, A. Über die Wirkung des Nipherschen Schutztrichters. p. 240–243. (Aug.)
Sandström, J. W. Klima und Topographie. p. 229–233. (Aug.)

Nature. London. v. 114. 1924.
Hill, Leonard. The cooling power of the air in trains, trams and buses. p. 246–247. (Aug. 16.)
Bonacina, L. C. W. The maximum recorded temperature of the air and its circumstances. p. 294–295. (Aug. 23).
Owens, J. S. The automatic measurement of atmospheric pollution. p. 330–332. (Aug. 30.)
Orchard heating in the United States. p. 370. (Sept. 6.)
Vegard, I. The light emitted from solidified gases and its relation to cosmic phenomena. p. 357–359. (Sept. 6.)
Bonacina, L. C. W. Barogram analysis in weather forecasting. p. 393–394. (Sept. 13.) [Discusses publications by Vercelli.]
[Cornish, Vaughan.] Wind, wave and swell on the North Atlantic Ocean. p. 394. (Sept. 13.)

Nature. Paris. 52 année. 30 août 1924.
Mathias, E. Les éclairs fulgurants. p. 132–133. [Repr. Comptes rendus.]

Nature magazine. Washington, D. C. v. 4. October, 1924.
Talman, Charles Fitzhugh. Hail and its half-brothers. p. 197–202.

Naturwissenschaften. Berlin. 12, Jahrgang. 1924.
Knoch, K. G. Hellmann als Forscher. p. 537–543. (4. Juli.)
Vegard, L. Über die Entstehung des Nordlichtspektrum. Bemerkungen zu dem Artikel des Herrn G. Cario. p. 673–674. (15. August.)

Royal aeronautical society. Journal. London. v. 28. August, 1924.
Tucker, W. S. Sound reception. 504–525. [Discusses various phenomena of atmospheric acoustics.]

Royal society of London. Proceedings. London. ser. A. v. 106. August, 1924.
McLennan, J. C., & Shrum, G. M. On the luminescence of nitrogen, argon, and other condensed gases at very low temperatures. p. 138–149.
Rayleigh, *Lord.* The light of the night sky: its intensity variations when analysed by colour filters. p. 117–137.

Science. New York. v. 60. 1924.
Putnam, George R. Thomas Corwin Mendenhall. p. 33–34. (July 11.) [Obituary.]
Henderson, Yandell. Musical echoes. p. 282–283. (Sept. 26.)

Scientific American. New York. v. 131. August, 1924.
Browne, Herbert Janvrin. Long-range weather forecasting. Predicting weather by the year in place of by the day. p. 82–83.
Platt, Haviland Hull. Atmospheric heat as a source of power. A suggestion of a means by which this reservoir might ultimately be tapped. p. 120.
The transatlantic voyage of "ZR-III." How she will evade the tornadoes and storms of the western ocean. p. 115.

Sirius. Leipzig. Bd. 57. Mai/Juni 1924.
Göschl, Franz. Über die Zulässigkeit der kosmischen Wettertheorie. p. 82–84.

Société astronomique de Bordeaux. Bulletin. Bordeaux. no. 6. 1923–24.
Mémery, Henri. Les variations periodiques annuelles des taches solaires et de la température. p. 7–12.

Wetter. Berlin. 41. Jahrg. 1924.
Grosse, W. Eine stetige kleine Klimaänderung im nordwesten Deutschlands. p. 89–94. (Mai/Juni.)
Milch, Wilhelm. Über den Trübungsfaktor für Sonnenstrahlung und seine Verwendung zur Wetterprognose. p. 78–82. (Mai/Juni.)
Peppler, W. Die Baar, ein lokales Kältezentrum. p. 85–86. (Mai/Juni.)
Peppler, W. Besonderheiten der Rheinebene. p. 86–87. (Mai/Juni.)
Peppler, W. Der Einfluss der Alpen. p. 84–85. (Mai/Juni.)
Peppler, W. Entwicklung sommerlicher Gewitterherde. p. 88–89. (Mai/Juni.)
Peppler, W. Vorübergang von Wärmefronten im Winter. p. 87. (Mai/Juni.)
Peppler, W. Wärmeentwicklung in der Rheinebene und Gewitterbildung. p. 88. (Mai/Juni.)
Peppler, W. Zwei Beispiele für den Einfluss des Bodenreliefs auf Witterung und Klima. p. 82–84. (Mai/Juni.)
Robitzsch, M. Eine charakteristiche Störung im jahrliche Temperaturgange in arktischen Gebieten. p. 73–78. (Mai/Juni.)
Schrepfer, Hans. Begriff, Methode und Aufgabe der Pflanzenphänologie. p. 65–73. (Mai/Juni.)
Ständer, F. Weinerträge von 1846–1913. p. 94–95. (Mai/Juni.)
Fischer, Rudolf. Kalte und milde Winter nach Anzahl der "Eistage" in Frankfurt a. M. seit 1826. p. 119–121. (Juli/August.)
Grosse. Der Sonnenschein in verschiedenen Klimaten. p. 114–119. (Juli/August.)
Kassner, C. Die ältesten Niederschlagsmessungen. p. 97–101. (Juli/August.)
Loges, M. Eine Unwetterkatastrophe in der Hainleite. p. 123–124. (Juli/August.)
P. Schäden durch Schneebelastung im Schwarzwald im vergangenen Winter. p. 122–123. (Juli/August.)
Schwalbe, G. Über die Verteilung der Temperatur über Deutschland im Winter 1923/24. p. 101–106. (Juli/August.)
Voights, Heinrich. Abriss der Geschichte des meteorologisch-wetterkundlichen Unterrichts in Deutschland vom Mittelalter bis zur Neuzeit. p. 106–113. (Juli/August.)

Zeitschrift für Instrumentenkunde. Berlin. 44. Jahrgang. August 1924.
Henning, F. Die Temperaturskala in Theorie und Praxis. p. 349–366.
Kolhörster, Werner. Die experimentallen Grundlagen der Messung der durchdringenden Strahlung. p. 333–349.

SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING AUGUST, 1924

By IRVING F. HAND, Acting in Charge Solar Radiation Investigations

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January and February, 1924, **53**: 42 and 113.

From Table 1 it is seen that solar radiation intensities averaged above normal values at all three stations.

Table 2 shows that the total solar and sky radiation received on a horizontal surface averaged above normal at Washington and close to normal at Madison and Lincoln.

Skylight polarization measurements made on 14 days at Washington give a mean of 56 per cent, with a maximum of 64 per cent on the 29th. Measurements obtained on 14 days at Madison give a mean of 65 per cent with a maximum of 71 per cent on the 27th. All these figures are slightly above the average August values, with the exception of the maximum for Washington which is close to normal.

TABLE 1.—*Solar radiation intensities during August, 1924*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	A. M.					P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	[1]1.0	2.0	3.0	4.0	5.0	e
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
August 5	17.37					1.14					17.37
6	20.57					1.13	0.77				16.79
7	19.89		0.57	0.71	0.86	1.14					16.79
9	16.79			0.76	0.99	1.26					15.11
14	11.38			0.88	1.13	1.47	1.20	1.05	0.92		10.21
15	9.47	0.80	0.92	1.06	1.22	1.42	1.22	1.00			9.75
18	9.14	0.86	0.96	1.08	1.22	1.39	1.10	1.00	0.87		7.29
19	10.21	0.72	0.86	0.97	1.11	1.25					7.87
21	17.96				0.79						16.20
27	13.13		0.57	0.73	0.95	1.25	1.02	0.83	0.68		13.13
29	11.81	0.72	0.85	0.98	1.14	1.35	1.11	0.94	0.79	0.68	13.13
30	14.60	0.71	0.82	0.92	1.10	1.33					15.65
Means		**0.76**	**0.79**	**0.90**	**1.05**	**1.28**	**1.01**	**0.88**	**0.73**	**(0.65)**	
Departures		**+0.10**	**+0.12**	**+0.13**	**+0.13**	**+0.06**	**+0.06**	**+0.08**	**+0.09**	**+0.03**	

[1] Extrapolated

TABLE 1.—*Solar radiation intensities during August, 1924*—Contd.

Madison, Wisconsin

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	A. M.					P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	e
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
August 11	10.97				1.22	1.45	1.25				9.47
12	9.47				1.19						11.38
13	10.21					1.45	1.25				7.87
14	9.14			0.96	1.19						9.14
20	14.10				1.13						14.60
23	13.13			1.06	1.19						12.68
26	15.65				1.06		1.14				17.96
27	12.68	0.88	0.98	1.10	1.25	1.47	1.27				10.21
28	11.38		0.95	1.06	1.19	1.37	1.22				12.68
29	12.24		0.89	1.01	1.18	1.27	0.91				15.11
Means		**(0.88)**	**0.94**	**1.04**	**1.18**	**1.40**	**1.17**				
Departures		**+0.14**	**+0.10**	**+0.10**	**+0.08**	**+0.09**	**+0.11**				

Lincoln, Nebraska

Date	8 a.m. e	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	Noon e
August 2	15.65					1.29	1.06	0.88	0.72		16.20
3	13.61	0.73	0.84	0.96			1.00	0.78	0.59		15.11
11	12.24					1.40	1.19	1.02	0.88	0.78	9.14
13	11.81				1.02	1.36					14.10
14	14.10				1.06	1.26					16.20
16	11.38		0.74	0.88	1.05						10.97
22	10.21						1.04	0.91	0.78	0.67	9.14
25	14.60		0.81	0.95	1.14	1.38	1.07	0.88	0.75	0.66	15.11
26	14.10		0.87	1.00	1.16	1.34	1.17	1.02	0.89	0.76	11.81
27	13.61				1.18	1.33	1.11	0.93	0.78	0.69	15.11
28	13.61	0.61	0.72	0.86	1.08	1.33					14.10
Means		**(0.67)**	**0.80**	**0.93**	**1.11**	**1.34**	**1.09**	**0.92**	**0.77**	**0.71**	
Departures		**−0.03**	**+0.01**	**+0.03**	**+0.03**	**+0.05**	**+0.01**	**+0.02**	**+0.01**	**±0.00**	

TABLE 2.—*Solar and sky radiation received on a horizontal surface*

[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation					Average daily departure from normal		
	Washington	Madison	Lincoln	Chicago	New York	Washington	Madison	Lincoln
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
July 30	458	357	406	368	395	−1	−113	−48
Aug. 6	481	400	448	285	392	+31	−55	−68
13	523	448	554	354	472	+88	+6	+59
20	329	486	558	379	305	−90	+67	+76
27	483	452	479	394	439	+78	+43	+10
Excess or deficiency on Sept. 2 since first of year						+1,107	−7,433	+2,962

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

The following table shows the average sea-level pressure for the month at a number of land stations on the coast and islands of the North Atlantic. The readings are for 8 a. m., 75th meridian time, and the departures are only approximate, as the normals were taken from the Pilot Chart and are based on observations made at Greenwich mean noon, or 7 a. m., 75th meridian time.

Stations	Average pressure	Departure
	Inches	*Inches*
St. Johns, Newfoundland	29.91	−0.08
Nantucket	29.98	−0.02
Hatteras	30.00	−0.04
Key West	29.97	−0.01
New Orleans	30.00	+0.02
Swan Island	29.86	−0.05
Turks Island	29.99	−0.01
Bermuda	30.13	−0.06
Horta Azores	30.29	+0.09
Lerwick, Shetland Islands	29.67	−0.13
Valencia, Ireland	29.90	−0.02
London	29.86	−0.12

It will be noticed that the pressure at Horta was slightly above normal and at Lerwick somewhat below, indicating that the monthly average gradient between the Azores HIGH and Icelandic LOW was steeper than usual. The barometric readings at Horta ranged from 30.40 inches on the 25th to 30.08 inches on the 31st, and at Lerwick from 30.23 inches on the 8th to 29.23 inches on the 19th.

Over the middle sections of the steamer lanes the number of days on which winds of gale force were reported did not differ materially from the normal as shown on the Pilot Chart. West of the 60th meridian, however, turbulent weather was more prevalent than usual, due to the disturbances of tropical origin that swept over these waters during the latter half of the month.

Fog was reported on about 15 days over the Grand Banks, and also in the vicinity of Nantucket; it occurred on from 5 to 9 days over the northern steamer lanes, while the European coast was comparatively clear.

On the 1st moderate depressions were central near 48° N., 49° W., and 55° N., 13° W., respectively. The western LOW moved but little during the next 24 hours while on the 2d the eastern depression was over the Irish Channel, and moderate winds prevailed in both localities. On the 4th and 5th a few vessels reported moderate gales north of the 50th parallel, accompanied by comparatively high barometer readings.

On the 6th there was a disturbance central near 43° N., 40° W., that moved slowly northeastward and on the 7th was in the vicinity of 48° N., 30° W.

From the 6th to the 8th moderate gales were reported from an extensive area over the eastern section of the ocean, as shown by following storm logs:

British S. S. *Duendes*, Newport News to Liverpool:

Began on the 5th, wind NE. Lowest barometer 29.35 inches at 5 a. m. on August 6, wind S., in 43° 32′ N., 40° 56′ W. End on the 6th, wind WSW. Highest force of wind, 8; shifts SSE.-WSW.

Dutch S. S. *Spaar*, Montreal to Marseille:

Began on the 8th, wind E. Lowest barometer 29.84 inches at 4 p. m. on the 8th, wind E., 8, in 36° 12′ N., 6° 42′ W. End on the 9th, wind E. Highest force of wind 8, E.; shifts E. by S.-E.

On the 8th and 9th easterly gales prevailed off the coast of southern Europe, as shown by the following storm log:

Danish S. S. *Texas*, Madeira to Copenhagen:

Began on the 9th, wind ENE., 8. Lowest barometer 30.04 inches, wind E., 9, in 44° 10′ N., 9° 24′ W. End on the 9th, wind ESE. Highest force of wind 10; shifts ENE.-E.-ESE.

On the 14th there was a depression near 40° N., 65° W., with moderate southerly gales in the easterly quadrants.

On the 15th a LOW appeared near 58° N., 20° W., which, traveling slowly eastward, developed into a severe disturbance, reaching its greatest intensity on the 17th, when central off the west coast of Ireland. Storm logs:

American S. S. *Saccarappa*, Galveston to Bremen:

Gale began on the 15th, wind SW., 7. Lowest barometer 29.94 inches at 4 a. m. on the 16th, wind NNW., 6, in 47° 15′ N., 27° 40′ W. End on the 18th, wind NNW., 6. Highest force of wind 9, SW.; shifts SW.-NNW.

German S. S. *Albert Ballin*, Hamburg to New York:

Gale began on the 16th, wind SSE. Lowest barometer 29.46 inches at 8 p. m. on the 16th, wind SW., 7, in 49° 34′ N., 11° 30′ W. End on the 17th, wind NW., 6. Highest force of wind 10; shifts SSE.-WSW.

On the 16th there was a depression in the vicinity of the Bermudas. Storm log:

Dutch S. S. *Barendrecht*, Rotterdam to Pensacola:

Gale began on the 16th, wind S. Lowest barometer 30.03 inches at 12:20 p. m. on the 16th, wind SW., 11, in 30° 36′ N., 64° 50′ W. End on the 17th, wind SW. Highest force of wind 11, SW.; steady SW.

On the 18th and 19th low pressure continued off the coast of Europe and westerly and northwesterly gales prevailed as far west as the 20th meridian. Storm logs:

German S. S. *Hannover*, Bremerhaven to New York:

Gale began on the 17th, wind SW., 6. Lowest barometer 29.36 inches at 4 a. m. on the 17th, wind SSW., 7, in 49° 57′ N., 5° 12′ W. End on the 19th, wind NW., 6. Highest force of wind, 9 W.; shifts W.-NNW.-NW.

From the 18th until the end of the month tropical disturbances prevailed that are described elsewhere in the REVIEW. A number of vessels were involved in these disturbances, but it is possible to quote only briefly from their reports,

The American S. S. *City of Freeport*, Spain to Cuba, encountered the first disturbance, as shown by following storm log:

Gale began on the 18th, wind ESE. Lowest barometer 29.71 inches at 5 p. m. on the 19th, wind SE., 7, in 23° 47′ N., 66° 48′ W. End on the 20th, wind SE. Highest force of wind 10, S. No shift of wind at time of lowest barometer; only shift occurred at 11 p. m. on the 19th.

Charts VIII to XV cover the period from the 21st to 28th, inclusive, and show the track of the tropical disturbance of that period along the American coast. Storm logs follow:

British S. S. *Mayari*, Boston to Preston and return:

Gale began on the 21st, wind NNW. Lowest barometer 29.33 inches at 2 p. m. on the 21st, wind WSW., 11, in 26° 40′ N., 73° 40′ W. End on the 2d, wind SW. Highest force of wind 11, WSW.; no shifts.

Swedish S. S. *Stockholm*, New York to Gothenburg:

Gale began on the 21st, wind WNW. Lowest barometer 29.53 inches at 4 a. m. on the 22d, wind NNE., 10, in 42° 02′ N., 64° W. End on the 22d, wind N. Highest force of wind 10, NNE.; shifts NNW.-N.-NE.

American S. S. *Harvester*, New York to Port Arthur:

Gale began on the 24th, wind ESE. Lowest barometer 28.74 inches on the 25th, wind E., 8, in 32° N., 76° 30′ W. End on the 26th, wind NW. Highest force of wind 12, ESE.; shifts E.-N.

Italian S. S. *Giuseppe Verdi*, Genoa to New York:

Gale began on the 26th, wind SE. Lowest barometer 29.11 inches at 1 p. m. on the 26th, wind SW., 12, in 39° 06′ N., 68° 06′ W. End at 9 p. m. on the 26th. Highest force of wind 12, SW.; shifts S.-SW.-W.

On the 29th there was a depression over Newfoundland that drifted very slowly eastward, and on the 31st was central near 47° N., 45° W. No winds of over force 6 were reported until the 31st, when vessels in the southerly quadrants reported moderate westerly gales. The British S. S. *Nitonian*, Liverpool to Kingston, encountered the second tropical disturbance, previously mentioned, as shown by following storm log.

Gale began on the 30th, wind ESE., 6. Lowest barometer 29.74 inches at 7:30 a. m. on September 1, wind S., 7, in 22° 05′ N., 66° 20′ W. End on September 2, wind S., 5. Highest force of wind 9, E.; shifts SE-S.

NORTH PACIFIC OCEAN

By WILLIS EDWIN HURD

The weather was remarkably quiet over the North Pacific Ocean during August, 1924, except in the Far East. The Aleutian LOW was at its lowest ebb for the year and practically nonexistent, and few cyclones from Asiatic sources advanced eastward even to the 180th meridian. The LOWS of the higher latitudes ran farthest north this month, their tracks only occasionally lying below the 50th parallel. The region surrounding Dutch Harbor was most affected by southward-moving cyclonic conditions on the 8th and 9th, and the Gulf of Alaska on the 21st to 25th. The high-pressure area of middle latitudes over the eastern half of the ocean remained permanent through August, and gales were exceedingly rare over the entire region.

The skies along the northern steamship routes remained cloudy; misty and drizzly weather was frequent, and fog was unusually prevalent. Some trans-Pacific vessels mentioned fogs as observed daily throughout a voyage. The U. S. S. *Bear*, cruising over eastern and northern Bering Sea during the early part of August, reported almost daily fog. On leaving Unalaska on the 16th, bound for San Francisco, the *Bear* during the following five days "encountered continuous fog and mist, clearing about ship at intervals, but always present in some direction in the immediate vicinity, rolling along in sheets." Along the American coast from San Diego northward fog occurred more frequently than during any previous month of the year, and was observed on more than 60 per cent of the days between 33° and 40° N. On the 20th fog was seen in 7° N., 83° W.

Owing to the permanence of the anticyclone in west longitudes the northeast trade, as a rule, was little disturbed. At Honolulu the prevailing wind was east. The maximum five-minute velocity was at the rate of 31 miles an hour from the northeast on the 17th, and the average hourly velocity was 10.6 miles, which is the highest on record for August.

Radiographic service from Dutch Harbor was interrupted, as in July, and it is impossible to give the true monthly pressure from that place. The average of 24 days was 29.91 inches, which is slightly above normal. Pressure continued above normal at Midway Island, the average being 30.11 inches (for 30 days), whereas the normal is 30.06. The highest reading, 30.20, was recorded on the 11th; the lowest, 29.96, on the 14th. Pressure was also high at Honolulu, being 30.05 inches, a departure of +0.06 inch. Compared with the daily normals the p. m. pressure was above normal except on 2 days, the 1st and 2d, when readings were equal to the normal. This record compares with that of Midway Island in the preceding July. The highest pressure, 30.13, occurred on the 30th; the lowest, 29.94, on the 27th.

Gales from north of the 35th parallel were reported by observers on only five days of the month—the 20th, 22d, 23d, 28th, and 31st—and did not in any instance exceed force 8. East of the 180th meridian, in addition to the moderate gales of the 28th and 31st, strong winds occurred on two other days in an unusual quarter. The British S. S. *Canadian Scottish*, Capt. A. Forson, Melbourne to Vancouver, ran into a tropical disturbance on the 4th in 16° 54′ N., 163° 15′ W. The following quotation is from the observer, Mr. A. S. J. Geen:

4th. Moderate NE. wind, increasing to force 5 from 3 a. m. to 8 p. m., then increasing to force 6, when the barometer read 29.82; 9 p. m., 29.70, wind increasing, sea rough; 10. p. m., 29.60, wind N 8; 11 p. m., 29.53, wind still increasing. At 11:30 p. m. wind NE. x N., barometer 29.47, strong gale. At midnight various light airs and clear sky till 12:20 a. m. (5th), then wind came from S., force 9, barometer starting to rise, 1 a. m., 29.52; 2 a. m., 29.59, S. 8; 3 a. m., 29.65, S. 7; 4 a. m., 29.72, SSE. 6; from 6 a. m. to noon wind SE. 6, barometer rising to 29.89, wind then easterly 4 to midnight.

From the Far East come reports of other tropical disturbances. The article on the typhoons of August by the Rev. José Coronas, of the Philippine Weather Bureau (see p. 403), describes the movements of several of these tropical storms. The following accounts are from reports of the marine observers of the U. S. Weather Bureau:

British S. S. *Tascalusa*, Hongkong to Yokohama, Capt. P. W. Trott; observer H. A. Arrowsmith, second officer:

August 4, midnight, 30° N., 132° 09′ E. Bar. 29.60, wind N. x E. 6, rough sea and rising with rain squalls; judged a typhoon was somewhere in the neighborhood. August 5, 1 a. m. Bar. 29.57, wind N. x E. 7, steady in direction, increasing in force, with heavy rain squalls. Bar. continued to fall steadily, wind to increase, with frequent heavy squalls to 10 a. m., when bar. 29.22, wind N. x E. 9, heavy sea from all directions, principally N. and E. Judged ship was on line of progression and in path of typhoon, so without further delay wind was brought on starboard quarter (using oil freely in getting ship off before wind and sea), and ship stood away to SW. Although ship was light draft, oil was freely used from forward W. C.'s with excellent results, considering the sea was from all directions, with a huge swell from E. and ship trembling and tossing fearfully. Noon, 30° N., 133° 28′ E. Bar. 29.15, wind 9, squalls less frequent; sea as before, but the huge swell had shifted to ESE. 1 p. m., bar. 29.10; wind had veered to NNW, 9, and course altered to keep wind on starboard quarter. 2 p. m., bar. 29.11; wind had veered to NW. 8; sea slightly more regular from NW.; course altered as before to keep wind on starboard quarter. 4 p. m., bar. 29.18; wind WSW. 6, sea moderating rapidly, with heavy swell from ESE. 8 p. m., bar. 29.47, wind SSW. 6, strong, moderating confused sea. Ship had been steered round the compass and was now on her course.

American S. S. *West Cajoot*, Manila to San Francisco:

4th. Wind NE. 3-7, large confused swell, rough sea. At 9.08 p. m. in 30° 52′ N., 137° 04′ E.

5th. Wind increasing to 10-12, violent squalls, high seas, confused swell, heavy rain showers. 4 a. m., pressure lowest, 29.30, wind ENE. 12, in 31° N., 137° 19′ E.

The tropical storm of August 7 to 23, described by Father Coronas as the "Loochoos typhoon" with the extraordinary track, on the 9th gave damaging floods in Taiwan, during which it was reported that 700 Japanese were drowned. A vivid account of this typhoon is furnished by Mr. S. Eriksen, second officer of the American S. S. *West Katan*, Capt. J. McAvoy, Hongkong to San Pedro:

August 10, 1924. About 10 a. m., 120th meridian time E., when vessel was passing Pakusa Pt. Lt., NW. coast of Formosa, Ci. clouds were observed extending in an E. and W. direction. Barometer 29.68, corrected, wind NNE. 2. A long, rolling, confused swell came up from the NE., and as vessel was passing the north coast of Formosa the wind freshened and a very warm breeze

commenced to blow from the westward. The northern horizon began packing with altostratus and nimbus clouds. At 10 p. m. the wind had increased to a strong breeze from the NW., with heavy confused cross seas and heavy rain squalls, and by midnight was blowing from WNW., force 9, with heavy rains. Barometer had been falling steadily since the morning watch, and at midnight was reading 29.44, very unsteady.

During the next day, August 11, the wind blew WNW. 8–10, with heavy rains and very rough confused sea, vessel laboring. Noon position, 25° 14′ N., 123° 06′ E. Strong WNW. gale, mountainous seas, heavy steady rain, barometer 29.34. At 8 p. m. the wind had increased to a whole gale from the WNW., barometer 29.08. Midnight, ship laboring heavily, pitching and rolling, heavy rain, barometer 28.90.

August 12. Wind now blew with hurricane force; vessel shipping seas fore and aft. The course steered should clear Providence Reef, off the north coast of Mayko Pima, Loochoo (Nansei) Islands, about 28 miles. 6 a. m., barometer 28.76 and very unsteady. 10:30 a. m., vessel passed into shallow water; wind blew with hurricane force. An attempt was made to heave vessel to, but she would only lay beam to wind, heading about N. true. Took soundings, which gave a depth of 14 fathoms, but immediately after sounding vessel past into deep water. 11:40 a. m., picked up NW. Rock, Providence Reef close aboard starboard bow. Engine rang full astern, backing away from rocks, which appeared to be all around. When vessel was in a central position, let go starboard anchor, 90 fth. chain, 25 fth. water, trying to get vessel head to wind and sea and working the engine ahead, thereby stopping her from drifting down on the reefs, but it proved a failure, as the vessel would only lay beam to wind, and was dragging the anchor. Hove in anchor chain and found anchor gone. Dropped port anchor, 120 fth. chain, 20 fth. water. Vessel was still drifting sideways. Engine worked ahead and astern to clear various inlaying reefs as they showed; wind blowing WNW. 12; visibility very poor.

Noon position, August 12, 25° 03′ N., 125° 15′ E. Barometer 28.35, unsteady and still falling. At 1 p. m. the barometer reached its lowest, 28.27, and after that began rising rapidly. Continuously sounding, and at 6:20 p. m. sounding showed 100 fths. Hove up port anchor and found it also gone. Between 4 p. m. and 6 p. m. wind decreased to a fresh gale from the NW., very rough confused sea. When soundings showed 100 fths. the vessel was considered clear of reefs and an easterly course was again set. 6 p. m., barometer 28.48. At 10 p. m. wind shifted to WSW. and began blowing with hurricane force. Midnight, barometer 28.92. Between 10 p. m., Aug. 12, and 2 a. m., Aug. 13, the wind was at its highest. At 4 a. m. wind shifted to SSW. 10, and by noon had decreased to force 5. Noon position, Aug. 13, 23° 34′ N., 128° 23′ E., barometer 29.35.

FIVE TYPHOONS IN THE FAR EAST DURING THE MONTH OF AUGUST, 1924

By Rev. José Coronas, S. J.

[Weather Bureau, Manila, P. I.]

There are five typhoons shown by our weather maps in the Far East during this month of August, only one having traversed the Philippine Islands.

Two Pacific typhoons: July 25 to August 7.—The first of these typhoons seems to have formed on July 25 to 27 over 300 miles to the west of the Ladrone Islands, not far from 139° longitude E. and 15° latitude N. After moving slowly to NNE. on the 28th and 29th it took a northwesterly direction on the 30th, its center being approximately situated at noon of August 1 in the neighborhood of 135° longitude E. and 25° latitude N. At 6 a. m. of the 3d the center was shown over the Eastern Sea near southwestern Japan and the northern Loochoos in about 30° latitude N., between 128° and 129° longitude E. The typhoon inclined then westward and probably filled up on the same day over the Eastern Sea between Shanghai and southwestern Japan.

The other Pacific typhoon appeared on August 2 west of the Ladrone Islands between 142° and 143° longitude E., 17° and 18° latitude N. It was a well-developed typhoon and well shown by the observation of Guam. It moved NNE. on the 2d; it recurved to N. and NNW. on the 3d, and W. on the 4th. The center as shown by the Bonins observations was situated on the 4th and 5th as follows:

August 4, 6 a. m., 144° 30′ longitude E., 27° latitude N.
August 4, noon, 143° 10′ longitude E., 28° 45′ latitude N.
August 5, 6 a. m., 136° 50′ longitude E., 28° 45′ latitude N.

After moving west for one day, the typhoon inclined WNW. in the afternoon of the 5th and NW. in the morning of the 6th. The center passed close to southwestern Japan on the early morning of the 6th and close to southwestern Korea in the early morning of the following day.

China Sea and Formosa typhoon: July 29 to August 7.—As stated at the end of my article for last month, this typhoon was shown by our weather maps on July 29 near 116° or 117° longitude E. and 18° or 19° latitude N. It moved westward for a while, very slowly, and recurved to N. and NNE. on July 31 to August 2 about 150 miles to the S. of Hongkong. The center crossed southern Formosa in the evening of the 3d; and then when near Meiacosima it recurved back to N. and W. again, crossing Formosa through the northermost part of the island during the night of 5th to 6th.

The Loochoos typhoon: August 7 to 23.—This typhoon remained for eight or nine days in the neighborhood of the Loochoos Islands, taking successively the following directions: W., SW., S., SE., E., NE., E., ESE., E., ENE., N., and WNW. The rate of progress of the typhoon during this period, particularly on the 13th, 14th, and 15th, was very small. The center of the typhoon appeared on the 7th to the SW. of the Bonins near 137° longitude E. and 24 latitude N. It moved to WNW. and reached the Loochoos on the evening or night of the 9th, when it began to follow the extraordinarily abnormal track as stated above. The center of this typhoon was shown at noon of the 19th over the Eastern Sea near 127° longitude E. and 30° latitude N. Hence it moved NNE., crossing the Korea Strait and the southeastern coast of Korea in the afternoon of the 20th. Once over the sea of Japan, it inclined eastward and traversed Japan through 39° latitude N. on the 22d.

The Luzon typhoon: August 22.—This is the first destructive typhoon that has visited the Philippines this year. It was probably formed from 300 to 500 miles to the east of San Bernardino Strait or of northern Samar. It moved WNW. and reached Luzon at about noon of the 22d, crossing the provinces of Neuva Ecija, Tarlac, Pangasinan, and Zambales, and doing considerable damage to the crops and properties in all these Provinces as well as in the northern part of the provinces of Pampanga and Bulacan. The direction of the typhoon to WNW. was kept through the China Sea on the 23d and through Hainan and the Gulf of Tongking on the 24th. The rate of progress of this typhoon on the 22d was about 19 miles per hour—very extraordinary for our latitudes. The center passed about 60 miles to the N. of Manila in the afternoon of the 22d. We have not received any barometric minimum from the very center of the typhoon. The lowest reported to us is that of San Isidro, Nueva Ecija, 739.94 mm., gravity correction not applied (29.13 inches). The position of the center on the 22d and 23d was as follows:

August 22, 6 a. m., 123° 45′ longitude E., 14° 45′ latitude N.
August 22, 2 p. m., 121° 30′ longitude E., 15° 20′ latitude N.
August 23, 6 a. m., 116° 25′ longitude E., 16° 55′ latitude N.
August 23, 2 p. m., 114° 15′ longitude E., 17° 40′ latitude N.

NINE OR TEN TYPHOONS IN THE FAR EAST DURING JULY, 1924

By Rev. José Coronas, S. J.

[Weather Bureau, Manila, P. I.]

No less than 9 or 10 typhoons were shown in our weather maps during last July, although only 2 passed very close to the Philippines and none of them did any considerable damage to our archipelago.

Two Loochoo typhoons.—The first typhoon of the month was the most important and the best developed. It was probably formed on the 5th to the ENE. of Guam, not far from 150° longitude E. and 16° latitude N. It moved practically W. until the afternoon or evening of the 8th, when it recurved to NW. and N. in the neighborhood of 130° longitude E. and 17° latitude N. From that time it went straight to the Loochoo Islands, striking Okinawa Islands, the central of the Loochoos, in the morning of the 11th. Observations received from Naha Observatory, Okinawa, through the courtesy of the director of Taihoku Observatory, Formosa, are as follows:

Date	Barometer	Wind
11th:	*Mm.*	*M. p. s.*
2 a. m.	738.4	ENE. 43.
6 a. m.	725.9	NE. 38.
Noon	726.5	S. 34.

From Okinawa the typhoon inclined to NNW. and WNW. across the Eastern Sea and entered China about 120 or 150 miles north of Shanghai during the night of the 12th to 13th.

The approximate positions of the center for 6 a. m. of July 7 to 13 are as follows:

July 7. 139° 45′ longitude E., 16° 35′ latitude N.
July 8. 133° longitude E., 16° 50′ latitude N.
July 9. 128° 50′ longitude E., 18° 30′ latitude N.
July 10. 128° longitude E., 20° 45′ latitude N.
July 11. 127° 45′ longitude E., 25° 20′ latitude N.
July 12. 124° 50′ longitude E., 30° 35′ latitude N.
July 13. 117° 30′ longitude E., 34° 05′ latitude N.

The other typhoon of the Loochoos was of much less importance. It appeared as forming on the 14th to 15th close to the Bashi Channel northeast of the Batanes Islands. After moving NE. on the 15th and morning of the 16th, it took a northerly direction between Ishigakihima and Naha, but it probably filled up on the 18th over the Eastern Sea to the E. of Shanghai.

Batanes and Formosa typhoon.—We are waiting for more observations and particularly for the official report of Taihoku Observatory, Formosa, in order to be sure of the track of this typhoon as shown by our weather maps. In case it be confirmed, it will have to be considered as the most peculiar and abnormal track ever observed in the Far East, at least in recent years.

The typhoon appeared on the 7th over the Pacific to the E. of the Batanes Islands, between 124° and 125° longitude E., 20° and 21° latitude N. It moved W. by N., traversing the Bashi Channel with this direction on the 8th; it was shown SW. of Formosa on the 9th; and on the 10th to 11th it was noticed moving back to ENE., crossing again the Bashi Channel into the Pacific. Then it went up northeast toward the southern part of the Loochoos, where it recurved again on the 13th to the N., NW., W., and SW., traversing Formosa with the latter direction during the night of the 15th to 16th. It continued moving SW. until the 18th, when it probably filled up near or over the Paracels.

Four typhoons of the Pacific.—All of these typhoons were of a few days duration. The first was shown by our weather maps to the west of Guam on the 13th, near 141° longitude E. and 14° latitude N. It moved N. on the 13th and 14th, and NW. on the 15th, filling up on the 16th between the Lochoos and the Bonins. The second typhoon was shown for two days on the 22d and 23d about 300 miles east of northern Luzon and the Balintang Channel. The other two typhoons were simultaneous from the 25th to the 29th: one moved northward 300 miles west of the Ladrone Islands between 15° and 20° latitude N., while the other moved NNW. to the E. of northern Luzon and Formosa. The latter was formed on the 25th to 26th near 127° longitude and 17° latitude, and filled up in about 122° longitude E. and 26° latitude N.

Three typhoons in the China Sea.—The first of these typhoons was formed on the 22d to 23d near 116° longitude E., and 19° latitude N.; it moved W. and reached the Hainan Strait on the 24th. The second was formed on the 26th west of northern Luzon near 116° or 117° longitude E. and 17° or 18° latitude N.; it movedf WNW. and filled up on the 28th or 29th near or over Hainan. The third typhoon appeared on the 29th near 116° longitude E. and 19° latitude N.; it moved westward for a while, but then it has remained almost stationary up to the present (August 1) in the neighborhood of 114° or 115° longitude and 19° latitude. Its further track will be described next month.

SOUTHWEST MONSOON IN ARABIAN SEA; GALES IN SOUTH PACIFIC OCEAN

By Albert J. McCurdy, Jr.

Arabian Sea.—Weather reports received from vessels that crossed the Arabian Sea during August indicate an increase in the activity of the southwest monsoon over that of the preceding month. Moderate to whole gales were experienced on somewhat more than one-third of the days for which reports have been received.

From the 2d to 6th the British S. S. *Clan Malcolm*, Capt. C. J. Higgins, Indian coast ports to New York, experienced southwesterly gales accompanied by rough and high seas in the vicinity of Socotra Island. Captain Higgins states that the lowest barometer, 29.60 inches, was recorded at 3:29 p. m. on the 4th in 12° 48′ N., 53° 45′ E. The wind at this time was SSW., force 10, later shifting to W. by S., and decreasing to force 2–3 on the 5th. But on the 6th, at 3:03 p. m., it had again increased to gale force from the SW. by W.

The Dutch S. S. *Vechtdijk*, Capt. K. Pann, Colombo to Suez, from the 2d to 5th experienced southwesterly winds of force 7. The observer, Mr. D. van du Horst, reports that the lowest pressure observed was 29.59 inches, occurring at 3:26 p. m. on the 5th in 11° 14′ N., 51° 30′ E.

On the 7th the American S. S. *Astral*, Capt. R. C. Doull, Port Said to Karikal, India, encountered a moderate to fresh southwesterly gale accompanied by heavy seas. Mr. S. K. Miller, second officer, reports that the lowest pressure observed was 29.76 inches (uncorrected), occurring at 3:47 p. m. in 13° 05′ N., 56° 45′ E. The wind at the time was SW., force 7 and 8.

The British steamships *Hyson* and *Suncliff* on August 13 and 16th, respectively, while in the vicinity of Socotra Island, experienced almost identical conditions to those reported by the *Astral*.

On the 20th and 21st the British S. S. *City of Naples*, Capt. H. Johnson, Penang to Colombo, experienced southwesterly winds of force 7 to 8, accompanied by rough seas. Mr. R. C. Cooper, observer, states that the lowest barometer recorded was 29.60 inches (uncorrected), occurring at 3:35 p. m. on the 21st in 12° 45′ N., 53° 49′ E.

South Pacific Ocean.—Of the several cyclonic disturbances reported in the South Pacific Ocean during August, only one of any significance occurred. This was a depression off the coast of Chile that appeared on August 20 and which until the 23d occasioned moderate to whole gales, with accompanying heavy snow and rain squalls. The Danzig S. S. *Gedania*, Capt. L. Schroeder, Buenos Aires to San Pedro, came within its influence on the 20th. Mr. F. Hesse, third officer, reports that the lowest pressure observed was 28.78 inches, occurring at 4 a. m. on the 20th in the Straits of Magellan. The wind at the time of lowest pressure was W. by N., force 7–8. By the 23d the gale had increased to force 8–10 from the southwest.

DETAILS OF THE WEATHER IN THE UNITED STATES

GENERAL CONDITIONS

The feature of the month was the very pronounced excess in precipitation over the upper Mississippi Valley and a much less excess over North Pacific Coast States, northwest Texas, and portions of the New England and Middle Atlantic States. (See inset on Chart IV.) This fact may or may not be significant of a return to normal rainfall in those regions that have experienced a shortage in the last few months.

Temperature was uniformly above normal in the South and in a less degree in some portions of the North. (See Chart III.) The usual details follow.

CYCLONES AND ANTICYCLONES

By W. P. DAY

There were few well-defined cyclonic disturbances charted over the United States during the month, the interchange between polar and equatorial air being evidenced in most cases by a line of discontinuity separating the northerly from the southerly winds in a trough of lower pressure moving eastward across the country. Within these troughs local areas of diminished pressure gave some evidence of cyclonic circulation and their day-to-day movement could be charted; but at all times the great troughs of which these low areas were a part were the important features of the weather charts.

On the other hand, over the adjacent portion of the Atlantic Ocean two tropical cyclones developed and reached hurricane intensity. A detailed description of these two storms is given under the section devoted to storms and weather warnings for the Washington Forecast District and also under the section headed "North Atlantic Ocean."

The high-pressure areas were mostly of the Alberta type, and were, as a rule, quite regular in movement and persistent as individual areas.

FREE-AIR SUMMARY

By V. E. JAKL, Meteorologist

Tables 1 and 2 well represent the upper-air conditions that prevailed at the six aerological stations during the month. As will be noted, the departures from normal were on the whole of almost negligible value. Furthermore, the record shows what is not revealed in the tables, that, with not many important exceptions, the conditions on individual days were practically the same as the averages for the month. This equable condition of the upper air naturally resulted from the lack of cyclonic activity during the month. (See Cyclones and Anticyclones above.)

Considering first the temperature, it is apparent that the lapse rate was of about normal value at all stations; consequently the slight departures in temperature that prevailed on the ground extended vertically with but little change. Therefore Chart III, this REVIEW, showing for the surface slightly cooler weather than normal over northern sections and slightly warmer weather over southern sections, applies as well to the upper air for sections east of the Rocky Mountains.

Relative humidity was quite uniformly normal or close to normal at all elevations at the various stations, which, combined with approximately normal temperatures, gave vapor pressures that were also about normal, as the computed results show in Table 1. However, the departures from normal in relative humidity and vapor pressure, unless of pronounced magnitude, are of little significance, inasmuch as the vapor content of the upper air can change rapidly, while the kite flights, on which the averages are based, are usually made in fair weather.

Winds, as shown by both kite and pilot-balloon observations, were generally about normal in direction and velocity, the usual direction for the greater portion of the country being from south to west. An approximate allocation of the normal winds for the month would be about southwest for the middle valley region and about west for the eastern portion of the country, with a general tendency toward veering somewhat with altitude. An important exception, however, in the prevalent winds for the month is noted at Due West, where there was a decided northerly tendency at moderate and high elevations, in marked contrast to normal westerly winds. This deviation from the normal direction at Due West may be attributed to the unusual pressure distribution prevalent over the southeastern portion of the country, where the normal August condition of high pressure extending from the Atlantic and diminishing westward was conspicuously absent during the greater portion of the month. (See Storms and Weather Warnings, New Orleans Forecast District, p. 411–412.) At Key West and San Juan, balloon observations showed resultant winds from an easterly direction at all altitudes, which probably represents the normal wind condition at those stations. Easterly upper winds were observed also at many other stations (except the more northerly ones), particularly in the latter portion of the month. Such occurrences of easterly winds, however, were too infrequent and were associated with too low velocities to show an appreciable easterly component in the monthly resultants for any level.

A number of instances of high velocity observed in two-theodolite pilot-balloon observations are recorded. The value of these observations lies in the undeniable proof they give that such velocities actually occur quite frequently, as the acceptance of such observations is not dependent on confidence in the normal behavior of the balloons. Moreover, such observations prove beyond dispute the existence of high velocities aloft on days when, from the surface barometric gradients, low velocities to great depth might be construed. Outstanding instances of high velocities observed during the month by the two-theodolite method are as follows: On the 4th, Ellendale showed in a two-theodolite observation, a wind increasing from 0.6 meter per second on the ground to 38 meters per second at 9,500 meters altitude; and on the 9th, a wind velocity of 3 meters per second on the ground, increasing to 40 meters per second at 8,000 meters altitude. Broken Arrow, in a two-theodolite observation on the 25th, showed a light wind averaging

about 4 meters per second extending up to 8,000 meters, above which there was a steady increase to 32 meters per second at 11,500 meters. On the same day (25th) a two-theodolite observation made at Groesbeck, 300 miles to the south of Broken Arrow, showed light winds from the ground to the upper limit of the observation, 14,000 meters above sea level. Incidentally, this record gives Groesbeck the distinction of obtaining the highest two-theodolite observation made during the month at any station, and showed an ascensional rate remarkably close to the adopted standard for single-theodolite work.

A series of two-theodolite observations made at Broken Arrow on the 18th shows the progressive change in wind direction and velocity up to high altitudes, attending the approach of a low-pressure area from the northwest. At 7 a. m. the low-pressure center was at Lander and at 7 p. m. over Pueblo. The aerological record given below is characteristic of the general type of pressure change represented by this low. The winds veered with altitude from southerly on the ground to northwesterly in the high altitudes, while at nearly all altitudes there was a well-defined veering in direction with time. Simultaneously with the veering in direction, there was a building up in wind force, the increase apparently progressing from both ends, i. e., from aloft and near the ground toward the middle altitudes, until at the last observation, there was a substantial increase in wind strength throughout the column, as compared with that shown in the first observation. The data are given in the following table:

Altitude m. s. l. (meters)	7 a. m.		11 a. m.		1:43 p. m.		3:26 p. m.		5:18 p. m.	
	Direction	Velocity (m. p. s.)	Direction	Velocity (m. p. s.)	Direction	Velocity (m. p. s.)	Direction	Velocity (m. p. s.)	Direction	Velocity (m. p. s.)
233	sse.	5	sse.	9	sse.	8	sse.	8	s.	9
500	s.	11	sse.	8	s.	10	sse.	9	s.	11
750	ssw.	12	s.	10	s.	11	s.	10	s.	12
1,000	ssw.	10	ssw.	11	s.	10	s.	10	s.	13
1,500	ssw.	8	ssw.	7	ssw.	11	ssw.	11	ssw.	11
2,000	s.	2	sw.	4	ssw.	10	ssw.	11	ssw.	10
2,500	sse.	2	ssw.	5	ssw.	7	sw.	7	sw.	8
3,000	sse.	3	ssw.	5	sw.	5	w.	6	w.	8
3,500	sse.	3	s.	5	w.	7	w.	9	wnw.	10
4,000	se.	3	s.	4	w.	7	wnw.	8	nw.	11
4,500	e.	3	ssw	5	wsw.	6	w.	8	nw.	12
5,000	se.	3	wsw.	4	wsw.	5	w.	10	nw.	11
6,000	ene.	4	sw.	3	nw.	10	nw.	11	nw.	6
7,000	w.	4	nw.	9	nw.	10	nnw.	9	nw.	7
8,000	w.	7	wnw.	9	nw.	14	wnw.	12	wnw.	12
9,000	wnw.	10	wnw.	14	nw.	9	wnw.	10	wnw.	12
10,000	wnw.	14	wnw.	12	wnw.	12	wnw.	15	wnw.	14
11,000			wnw.	13	wnw.	14	wnw.	15	wnw.	12
12,000			wnw.	16	wnw.	14	wnw.	17		
13,000					wnw.	12	wnw.	15		

A series of kite flights made at Drexel on the 14th shows the sequence of meteorological conditions during a period of about 16 hours preceding a severe thunder storm. At 7 a. m. of this date, corresponding in time with the first observation, Drexel was in front of an extensive area of low pressure consisting of a number of more or less well-defined centers. By 7 a. m. of the 15th, Drexel lay to the southeast of the center of a small area of low pressure. The aerological record shows at first a rise in temperature at most altitudes, and then a moderate fall, the fall apparently occurring at progressively higher altitudes. Coincidentally with the deepening of the column of falling temperature the point of highest humidity rose in altitude, the last flight giving a record of 94 per cent at 2,780 meters altitude [not shown in table]. It can be plausibly inferred that a deep column of moist air having an adiabatic lapse rate was eventually built up by this process, from which rain necessarily followed. The surface meteorological record shows that rain began soon after the last flight, but that the heaviest rain fell during a brief period when the surface wind, which was generally south, became southwest. The circumstance of this brief downpour is undoubtedly an example of the underrunning effect of an abrupt change in wind direction, typical of the squall line in the southern portion of some depressions. Temperatures, humidities, and wind directions for this series of flights are given in the following table:

Altitude m. s. l. (meters)	8 a. m.			11 a. m.			3 p. m.			9 p. m.		
	Temperature (° C.)	Relative humidity (per cent)	Wind direction	Temperature (° C.)	Relative humidity (per cent)	Wind direction	Temperature (° C.)	Relative humidity (per cent)	Wind direction	Temperature (° C.)	Relative humidity (per cent)	Wind direction
396	16.9	82	s.	25.0	72	s.	27.7	71	se.	25.5	80	sse.
500	17.6	81	s.	24.2	73	s.	26.9	69	sse.	24.5	74	s.
1,000	19.5	79	ssw.	20.5	80	sse.	23.1	70	s.	20.7	58	sw.
1,500	16.7	93	sw.	18.3	89	ssw.	19.2	81	ssw.	18.3	59	sw.
2,000	16.4	45	wsw.	15.5	53	sw.	17.2	87	ssw.	15.1	59	sw.
2,500	12.9	49	wsw.	14.3	48	sw.	12.2	85	ssw.	11.5	70	sw.
3,000	9.3	52	wsw.	10.9	51	sw.	9.8	65	ssw.			
3,500	5.8	56	wsw.	7.6	53	sw.	7.1	51	ssw.			
4,000							4.4	39	sw.			

Table 1.—*Free-air temperatures, relative humidities, and vapor pressures during August, 1924*

TEMPERATURE (°C.)

Altitude m. s. l. (*m.*)	Broken Arrow, Okla. (233 *m.*)		Drexel, Nebr. (396 *m.*)		Due West, S. C. (217 *m.*)		Ellendale, N. Dak. (444 *m.*)		Groesbeck, Tex. (141 *m.*)		Royal Center, Ind. (225 *m.*)	
	Mean	Departure from 7-yr. mean	Mean	Departure from 9-yr. mean	Mean	Departure from 4-yr. mean	Mean	Departure from 7-yr. mean	Mean	Departure from 6-yr. mean	Mean	Departure from 7-yr. mean
Surface	27.1	0.0	22.7	+0.1	25.5	−0.1	19.4	−1.1	27.7	+0.8	24.0	+0.2
250	27.0	0.0			25.2	0.0			26.7	+0.7	23.7	+0.1
500	25.8	+0.2	22.2	0.0	23.0	+0.3	19.2	−1.1	24.8	+0.6	21.5	+0.1
750	24.7	+0.3	21.5	+0.1	21.6	+0.5	18.2	−1.2	23.7	+0.6	19.7	0.0
1,000	23.6	+0.5	20.8	+0.4	20.0	+0.5	17.1	−1.1	22.9	+0.8	18.3	+0.1
1,250	22.1	+0.5	19.9	+0.7	18.5	+0.5	16.2	−0.7	21.7	+0.9	16.9	+0.2
1,500	20.6	+0.6	18.8	+0.9	17.1	+0.6	14.9	−0.6	20.5	+1.1	15.4	+0.1
2,000	17.2	+0.7	16.4	+1.5	13.8	+0.4	12.3	−0.3	18.0	+1.5	13.1	+0.5
2,500	13.7	+0.6	13.6	+1.9	10.4	+0.3	9.3	−0.4	15.3	+1.6	10.1	+0.1
3,000	10.7	+0.8	10.4	+2.1	6.9	−0.3	6.5	−0.4	13.0	+2.0	7.0	−0.3
3,500	6.9	+0.5	7.2	+2.2	3.4	−0.9	3.6	−0.4	10.7	+2.1	4.7	0.0
4,000	3.7	+0.6	4.1	+2.4	0.8	−0.1	1.0	−0.1	7.9	+1.9		
4,500	0.5	+0.9	0.6	+2.5			−2.2	−0.1				
5,000	−2.4	+0.9	−2.1	+3.0			−4.4	+0.4				

RELATIVE HUMIDITY (%)

Surface	68	+2	72	+2	72	+1	65	0	71	−2	66	+1
250	68	+2			72	+1			73	−1	66	+1
500	64	0	68	+1	74	0	64	0	75	+1	67	+2
750	63	+1	63	+1	74	−1	60	0	68	0	69	+3
1,000	61	0	59	−1	73	−3	58	0	58	−4	70	+4
1,250	61	0	58	−1	72	−4	55	−2	57	−3	69	+3
1,500	62	+1	57	−1	69	−6	55	−2	55	−5	68	+3
2,000	63	0	54	−4	69	−2	55	0	51	−8	59	−2
2,500	65	+2	51	−7	72	0	52	−1	49	−8	56	0
3,000	65	+3	50	−8	78	+6	53	+1	42	−11	54	+4
3,500	65	+3	53	−5	82	+10	51	+1	35	−12	47	+1
4,000	67	+3	45	−10	76	+5	49	−1	27	−11		
4,500	68	+4	49	−7			46	−3				
5,000	72	+4	47	−10			44	−2				

VAPOR PRESSURE (*mb.*)

Surface	24.20	+1.20	19.98	+1.17	23.38	+0.33	14.16	−0.93	25.82	+0.45	19.64	+0.58
250	23.99	+1.17			23.02	+0.30			25.03	+0.48	19.44	+0.60
500	21.18	+0.77	18.61	+0.83	20.82	+0.52	13.79	−0.98	22.99	+0.76	17.34	+0.70
750	19.34	+0.99	16.32	+0.60	19.03	+0.42	12.20	−0.99	19.60	+0.37	16.24	+0.99
1,000	17.64	+0.88	14.63	+0.43	17.22	+0.09	10.89	−1.05	16.10	−0.50	15.08	+1.03
1,250	16.15	+0.85	13.51	+0.56	15.38	−0.28	9.79	−1.06	14.82	−0.13	13.47	+0.64
1,500	14.87	+0.97	12.29	+0.52	13.68	−0.38	8.94	−0.91	13.38	−0.35	11.97	+0.47
2,000	12.18	+0.68	9.89	+0.11	11.16	+0.17	7.59	−0.34	10.55	−0.70	8.57	−0.42
2,500	9.98	+0.74	7.52	−0.45	8.94	+0.01	6.20	−0.21	8.64	−0.61	5.95	−1.04
3,000	8.04	+0.70	5.68	−0.80	7.46	+0.14	5.35	+0.09	6.56	−0.90	4.16	−0.99
3,500	6.14	+0.43	4.80	−0.40	6.13	+0.23	4.51	+0.21	4.81	−0.95	2.44	−1.55
4,000	4.98	+0.47	3.44	−0.54	4.75	+0.11	3.85	+0.26	3.31	−0.91		
4,500	3.84	+0.62	2.79	−0.28			3.16	+0.21				
5,000	2.87	+0.62	2.00	−0.38			2.61	+0.21				

Table 2.—*Free-air resultant winds (m. p. s.) during August, 1924*

Altitude, m. s. l. (m.)	Broken Arrow, Okla. (233 meters)				Drexel, Nebr. (396 meters)				Due West, S. C. (217 meters)				Ellendale, N. Dak. (444 meters)				Groesbeck, Tex. (141 meters)				Royal Center, Ind. (225 meters)			
	Mean		7-year mean		Mean		9-year mean		Mean		4-year mean		Mean		7-year mean		Mean		6-year mean		Mean		7-year mean	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S. 2° W.	4.2	S. 2° W.	3.5	S. 14° E.	2.1	S. 15° E.	1.7	N. 34° W.	0.6	S. 25° W.	0.1	S. 76° W.	1.4	S. 46° W.	0.8	S. 17° W.	3.2	S. 15° W.	3.1	S. 35° W.	1.6	S. 60° W.	1.5
250	S. 2° W.	4.3	S. 1° W.	3.6					N. 37° W.	1.0	S. 52° W.	0.2					S. 16° W.	4.0	S. 17° W.	4.1	S. 38° W.	1.8	S. 62° W.	1.7
500	S. 3° W.	6.4	S. 12° W.	5.2	S. 29° E.	2.9	S. 11° E.	2.2	N. 19° W.	1.5	N. 84° W.	0.6	S. 61° W.	2.1	S. 36° W.	1.2	S. 16° W.	5.8	S. 22° W.	5.9	S. 49° W.	3.2	S. 65° W.	3.6
750	S. 13° W.	7.4	S. 19° W.	5.8	S. 7° E.	4.3	S. 4° W.	3.2	N. 11° W.	1.7	N. 78° W.	0.8	S. 58° W.	3.3	S. 37° W.	2.1	S. 15° W.	6.7	S. 21° W.	6.0	S. 47° W.	5.3	S. 70° W.	4.5
1,000	S. 18° W.	7.9	S. 27° W.	6.2	S. 5° W.	4.5	S. 21° W.	3.3	N. 5° W.	1.7	N. 78° W.	0.7	S. 74° W.	3.3	S. 49° W.	2.4	S. 17° W.	6.6	S. 21° W.	5.9	S. 62° W.	6.2	S. 77° W.	5.6
1,250	S. 24° W.	7.3	S. 34° W.	5.9	S. 36° W.	5.2	S. 48° W.	3.1	N. 2° E.	2.0	N. 81° W.	1.0	S. 73° W.	3.7	S. 59° W.	2.8	S. 20° W.	6.6	S. 22° W.	5.7	S. 68° W.	7.2	S. 83° W.	6.4
1,500	S. 30° W.	7.9	S. 40° W.	5.7	S. 43° W.	5.4	S. 50° W.	3.9	N. 9° W.	2.3	N. 87° W.	1.9	S. 76° W.	4.6	S. 68° W.	3.4	S. 18° W.	6.1	S. 19° W.	5.0	S. 76° W.	7.8	S. 87° W.	7.2
2,000	S. 36° W.	6.9	S. 45° W.	5.1	S. 56° W.	6.2	S. 66° W.	5.2	N. 35° W.	3.1	N. 79° W.	2.7	S. 88° W.	5.1	S. 84° W.	4.6	S. 10° W.	5.5	S. 12° W.	4.2	S. 78° W.	8.9	S. 87° W.	8.1
2,500	S. 37° W.	6.0	S. 50° W.	5.1	S. 63° W.	9.2	S. 73° W.	6.7	N. 62° W.	4.5	N. 82° W.	4.0	S. 89° W.	7.3	N. 88° W.	8.9	S.	5.0	S. 14° W.	4.2	S. 81° W.	10.5	N. 88° W.	9.4
3,000	S. 36° W.	5.6	S. 50° W.	5.7	S. 66° W.	11.6	S. 81° W.	8.5	N. 65° W.	4.5	N. 87° W.	5.6	N. 88° W.	9.5	N. 81° W.	8.4	S. 11° W.	5.0	S. 20° W.	4.5	S. 75° W.	13.6	N. 86° W.	11.1
3,500	S. 35° W.	6.5	S. 46° W.	6.8	S. 71° W.	13.5	S. 82° W.	9.7	N. 80° W.	8.3	S. 88° W.	7.7	N. 88° W.	12.0	N. 79° W.	11.0	S. 6° W.	5.5	S. 12° W.	5.1	S. 76° W.	14.0	N. 89° W.	11.1
4,000	S. 35° W.	6.7	S. 55° W.	8.3	S. 84° W.	14.2	S. 88° W.	11.1	W.	8.8	N. 87° W.	8.9	N. 87° W.	13.1	N. 77° W.	11.5	S.	6.7	S. 11° E.	3.2	S. 82° W.	14.8	S. 87° W.	12.6
4,500	S. 49° W.	7.8	S. 62° W.	7.5	N. 81° W.	10.2	N. 71° W.	10.5	W.	8.2	N. 86° W.	11.2	N. 73° W.	15.4	N. 75° W.	11.9	S.	4.3	S. 34° E.	7.8				
5,000	S. 68° W.	16.0	S. 68° W.	16.0	N. 49° W.	11.8	N. 65° W.	12.8			S. 67° W.	18.4	N. 67° W.	14.4	N. 82° W.	12.8								

THE WEATHER ELEMENTS

By P. C. Day, Meteorologist in Charge of Division

PRESSURE AND WINDS

The distribution of the atmospheric pressure during August, 1924, showed no important deviation from that usually prevailing during the summer months, save for the large number of slight cyclonic depressions that persisted over the lower Missouri and upper Mississippi Valleys, particularly during the first decade. These usually developed only slight pressure gradients, but were attended by frequent thunderstorms, locally heavy rains, and, as a rule, pursued short courses toward the upper Lakes, where they mainly disappeared. Slight barometric depressions were rather frequently observed over the southwestern districts, but these likewise usually developed little strength, pursued short courses, and brought but little precipitation to those districts.

The anticyclones of the month, as in the preceding July, were the dominant feature of the atmospheric circulation, and, though they developed little prominence, pursued rather definite courses across the country.

The average pressure for the month was slightly higher than normal over the Pacific Coast States, in portions of the lower Mississippi Valley, and along the west Gulf coast. Elsewhere, including Canada, the average pressure was mainly less than normal.

Compared with the preceding month the average pressure was less in practically all parts of the country, only a small area over the extreme Northeast, including the Canadian Maritime Provinces, having averages materially higher than those of July.

Due to the absence of important cyclones or anticyclones the wind circulation was mainly moderate, and such high winds as occurred were usually associated with thunderstorms, except along the immediate Atlantic coast where some high winds occurred on the 25th and 26th in connection with a tropical storm that moved northeastward near the coast during that period. This storm was particularly severe along portions of the coast from New Jersey to southern New England. At Block Island it was reported as the worst summer storm ever experienced at that place, and other points in the vicinity suffered severely from the wind and high waters.

The prevailing wind directions were mainly from southern points over the Great Plains and to the eastward, save over the more northern districts where they were from the west or northwest. Elsewhere they were variable, as is usual.

TEMPERATURE

The important feature of the temperature distribution during the month was the continued cool weather over the north central districts, which had persisted with more or less constancy from early in May until about the end of the second decade of August.

The first few days of the month were distinctly cool from the upper Mississippi Valley eastward and likewise over the Plateau and Pacific Coast States, but it was mainly warm in the central valleys and Southern States, the period being particularly warm in the central and southern Great Plains.

The week ending August 12 was cool throughout over nearly all districts from the Great Lakes and middle Mississippi Valley westward to the Pacific, but the temperatures higher than normal continued in the South, and decidedly warmer weather overspread the more eastern districts, the maximum temperatures rising above 100°, the highest for the month, in portions of the Middle Atlantic States. The week ending August 19 continued cool over all northern and most central districts, the week being decidedly cool, 6° to 9° below normal, from the northern Plains eastward to the Great Lakes and Ohio Valley. Warm weather continued during most of this period in the South, particularly from Texas and Oklahoma westward to Colorado and eastern Arizona.

The cool weather that had persisted for so many weeks over much of the central and northern portions of the country from the Rocky Mountains eastward terminated near the end of the second decade of the month, and the average temperature for the week ending August 26 was above normal over practically all districts from the Rocky Mountains eastward, the period being unusually warm over the central and southern Rocky Mountains and thence eastward to the Ohio Valley and Middle Gulf States, where locally the highest temperatures of the summer were observed and in some cases the highest ever observed in August. From the 26th to the end of the month the temperature was mainly above normal throughout, save for the last day or two, when cool weather overspread the Northwest. Over portions of the Atlantic coast this period was locally the warmest of the summer, and likewise in the interior valleys of California, where some damage to drying fruit resulted, particularly raisins.

For the month as a whole the temperature averages were below or only slightly above normal from the Great Lakes westward to Washington and Oregon, and over central and southern California and apparently over all

of western Canada. The month was moderately warmer than normal over practically all central portions from the Rocky Mountains eastward, while in most southern districts it was much warmer than normal; in fact, over many parts of this area the daily means were above normal practically every day, the monthly means were the highest of record for August, and in some cases the highest for any month in many years.

Maximum temperatures of 100° or higher were reported from all the States, save in the upper Lake region and New England, the highest observed, 124°, occurring in the desert region of California.

Temperatures slightly below freezing were reported from practically all the northern border States, and they were materially below at exposed localities in all the western mountain States, the lowest observed, 12°, occurring in Idaho.

PRECIPITATION

The precipitation for the country as a whole was greatly deficient, although a few sections had amounts far in excess of the usual fall.

Precipitation was frequent and locally heavy in the lower Missouri and upper Mississippi Valleys and the adjacent areas of the upper Lake region during the first two decades, and in portions of this area rains continued at short intervals until near the middle of the last decade, and fell again at the end of the month. In nearly all other portions of the country precipitation was less than normal or only slightly in excess. In most of the Southern States precipitation was greatly deficient and the month as a whole was among the driest, and, in some cases, the driest of record for August.

In portions of the east Gulf States, notably in Georgia and near-by districts, the long periods without material precipitation with the intense heat produced drought conditions of unusual severity, and crops deteriorated rapidly toward the end of the month. Likewise in Louisiana and portions of adjacent States the month was among the driest of record, and drought conditions that began early in the summer were not relieved until after the end of the month.

In Colorado and thence westward over the Plateau region the month continued dry and over the greater part of this region the season so far has been the driest for many years.

Farther west, there were some good rains in parts of northern California on the 18th and 19th, but over the greater part of the State severe drought continued at the close of the month. Water shortage increased, and the deepening of old wells and digging of new ones to relieve the situation continued. Steam-power plants continued in operation to increase the production of electric energy; water for irrigation was insufficient and crops in many localities steadily declined from lack of water and from high temperatures, particularly near the end of the month; pastures became short; and conditions were favorable for forest fires.

On the other hand, the month was unusually wet in the lower Missouri and upper Mississippi Valleys and portions of the upper Lake region. In some localities of these areas the daily falls were unusually heavy, notably in the vicinity of Milwaukee, Wis., where the total fall was the greatest of record for August, the fall for the period from the 3d to 6th aggregating in some cases nearly 10 inches, resulting in severe floods. Also northern Illinois and eastern Iowa had heavy to excessive precipitation, attended locally by high wind and hail, causing much damage by flood and otherwise.

SNOWFALL

The only snowfall observed, as far as reports indicate, occurred in the mountains of Wyoming, where one station reported a measurable amount and several others had traces.

RELATIVE HUMIDITY

The percentage of relative humidity was nearly everywhere less than normal; the only section reporting an appreciable excess embraced the Missouri and upper Mississippi Valleys, portions of the Great Lakes region, and the interior section of New York and New England. In the Southern States the values were in some cases as much as 20 per cent less than normal, and deficiencies nearly as great were reported from portions of the Plateau and Rocky Mountain sections.

SUNSHINE AND CLOUDS

Generally there was abundant sunshine except over the upper Mississippi Valley, the Great Lakes region, southern Florida, and the far Northwest. In the interior portion of California the sunshine was almost continuous and there was a high percentage over portions of the Southern Plains, the lower Mississippi Valley and elsewhere in the South.

SEVERE LOCAL HAIL AND WIND STORMS, AUGUST, 1924

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path, yards [1]	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Williston, N. Dak.	1					Thunderstorm and wind.	Considerable structural damage done.	Official, U. S. Weather Bureau.
Abilene, Kans.	1	4 p. m.	3,520		$40,000	Hail	Much destruction of gardens, greenhouses, window panes, and auto tops; some stones 5.5 inches in diameter.	Do.
Ellinwood, Kans.	1	4 p. m.	6–10 mi.		20,000	do	Fruit, gardens, corn, wheat stacks, and trees damaged.	Do.
St. Paul, Minn.	2	8 a. m.				Wind	Power lines, trees, signs, and roofs damaged; 1 person injured.	Dispatch (St. Paul, Minn.).
Hardin and La Rue Counties, Ky.	2	10 a. m.–2 p. m.		1	25,000	Hail, wind, and rain.	Corn and tobacco badly damaged; some destruction by flooding.	Official, U. S. Weather Bureau.
Northeastern Wisconsin	3				110,000	Wind and rain	Small grains lodged, corn damaged, numerous washouts, traffic delayed; cherry growers heaviest losers.	Do.
Cherry and Brown Counties, Nebr.	3	10 p. m.	1,760			Hail	Hay damaged, roofs punctured; prairie chickens and wild ducks killed.	Do.
Southern Wisconsin	3–4					Rain, wind, and electrical.	Severe crop damage; traffic delayed; many fires caused by lightning, communication lines crippled, and much damage by flooding.	Official, U. S. Weather Bureau; Green Bay (Wis.) Press Gazette.
Southern part of Hardin, and northern part of Marion Counties, Ohio.	4				20,000	Wind and electrical.	Buildings damaged, orchards and crops injured.	Official, U. S. Weather Bureau.
Southeast Henry County to Putnam County, Ill.	4		0.5–5 mi.			Wind, rain, and hail.	Trees and wires blown down, crops injured, and several fires from lightning; much damage by floods.	Do.
Norton, Cheyenne, and Thurman Counties, Kans.	4					Wind	A considerable number of barns, outbuildings, and windmills blown down; destruction over extensive area.	Do.
Mitchell, Iowa	4	7 p. m.	3,520		5,000	Hail	Some crop damage	Do.
Charles City, Iowa, and vicinity.	4	1–6:30 a. m.				Thunderstorm	Store and several barns damaged by lightning	Do.
Ludington, Mich.	5	4–6:25 p.m.				do	Several buildings struck by lightning; communication lines crippled.	Official, U. S. Weather Bureau; Ludington Daily News.
Davenport, Iowa, and Moline and Rock Island, Ill.	5	6 p. m.				do	Streets undermined; street cars disabled; communication lines and crops considerably damaged.	Official, U. S. Weather Bureau.
Dodge City, Kans. (3.5 mi. se. of).	5	4 p. m.		1		do	5 horses killed; no other damage reported	Do.
Knowles, Wyo.	6					Heavy hail	Corn and gardens damaged	Do.
Peetz (near), Colo.	6	3 p. m.	5 mi.			Hail	Poultry killed; minor property damage	Do.
Custer, Valley, Hall, and Nance Counties, Nebr.	7	4–8 a. m.	1–3 mi.		25,000	do	Gardens and crops destroyed, chickens killed	Do.
Eastern Sheridan and western Cherry Counties, Nebr.	7	9:30 p. m.	220–3,520	1		Small tornado	Haystacks, buildings, windmills, and fences wrecked or damaged.	Do.
Hampshire (near), Wyo.	7	5 p. m.	1,760			Heavy hail and wind.	Nearly all crops destroyed; many chickens killed.	Do.
Merrillan, Wis.	7	6 p. m.	1,760		2,000	Heavy hail	Damage principally to roofs	Do.
Sand Creek, Wis.	7	7 p. m.	330			do	Severe; crops total loss	Do.
Trempealeau and Jackson Counties, Wis.	7	6:30–7 p. m.	333–1,760	4	200,000	Tornado	Path 27 miles long; houses and farm buildings destroyed; crops heavily damaged.	Do.
Chippewa County, Wis.	7	7 p. m.	330	3		Tornado and hail.	Path 8 or 10 miles long: hail much more extensive; about 100 persons injured; farm houses and buildings destroyed: great damage to crops.	Do.
Hartford County, Conn.	7			1	250,000	Wind, rain, hail, and electrical.	Hundreds of acres of tobacco destroyed, barns burned, wire systems crippled, and other property damage.	Official, U. S. Weather Bureau; Hartford Courant (Conn.).
Northern Illinois and eastern Iowa.	7–8			2		Wind, rain, and hail.	Extensive property and crop loss	Official, U. S. Weather Bureau.
Dundy County, Nebr.	8	8:30 p. m.	4 mi.			Hail	Damage severe in spots	Do.
Western Cherry and eastern Sheridan Counties, Nebr.	8					Small tornado	Some damage to buildings and fences	Do.
Otrum, Wis.	8	5 p. m.	1,760			Heavy hail	50 per cent crop loss	Do.
Between Osseo and Alma Center, Wis.	8	4 p. m.	1–2 mi.		10,000	do	Character of damage not reported; very large stones.	Do.
Troy (near), Kans.	8	5 p. m.				Hail	Apple and grape crops injured	Do.
Miltonvale (near), Kans.	8	P. m.				Violent wind	Small buildings wrecked; chickens and horses killed.	Do.
Toledo, Ohio	8					Wind	Trees, wires, and a few buildings damaged	Do.
Terre Haute, Ind.	8–9					Thunderstorm	Trees down, telegraph and telephone service interrupted.	Do.
Torrington, Wyo.	9	9–9:20 p. m.	1,760		17,000	Heavy hail	Beets, potatoes, grains, and meadows injured 12 to 50 per cent.	Do.
Tulsa, Okla.	9	P. m.			250,000	Wind, rain, and electrical.	Lightning struck oil tanks, causing disastrous fire.	Tulsa World (Okla.).
Thurman (near), Colo.	10			10	8,000	Tornado	All farm buildings and crops in path destroyed; 3 autos wrecked; chickens and hogs killed.	Official, U. S. Weather Bureau.
Mohawk and Schoharie Valleys, N. Y.	10					Hail and wind	Heavy losses in property and crops	Do.
Eureka Springs, Ark.	10	7–9 p. m.				Moderate hail	Damage principally to windows	Do.
Little Island (near), Avoyelles Parish, La.	11	4 p. m.	880	1		Tornado and hail.	3 persons injured; some houses and trees blown down.	Do.
Evelyn, Ky.	11					Thunderstorm with hail.	Corn and tobacco crops injured	Do.
Greensburg, Ky.	11					do	Severe damage by hail to tobacco and corn crops.	Do.
Woodward, Okla., and vicinity.	12					Wind, rain, and hail.	Many farm buildings unroofed, some wrecked; 3 horses killed; corn stripped.	Do.
Ford County, Kans.	12	4:18 p. m.	1–4 mi.		50,000	Violent wind and hail.	Crops injured; poultry killed; windmills and outhouses blown down; heaviest loss in town of Wright.	Do.
Clark and Comanche Counties, Kans.	12	6:30 p. m.	880–1,320		100,000	do	Most severe storm ever known in vicinity; roofs riddled; corn ruined.	Do.
Omaha, Nebr.	12					Wind and hail	Considerable destruction of property	Do.
Council Bluffs, Iowa	12	12:15 p. m.	4 mi.			Hail	Severe damage to truck crops	Do.
Camden, N. Y.	13	2–3 p. m.				Electrical, hail and wind.	Roof torn from storage shed, trees uprooted, wires tangled.	Post Standard (Syracuse, N. Y.).
Merrick, Hamilton, Clay and Nuckolls Counties, Nebr.	13	5:30–7 p. m.	2–4 mi.			Hail	Windows and roofs damaged; crops considerably damaged in places; some chickens and pigs killed.	Official, U. S. Weather Bureau.
Peetz, Colo.	13	4–4:30 p.m.	5 mi.			do	Loss of crops valued at $25 per acre; 30 per cent of land in corn, which is a total loss; windows and roofs also damaged.	Do.

[1] Yards when not otherwise specified; "mi." signifies miles.

SEVERE LOCAL HAIL AND WIND STORMS, AUGUST, 1924—Continued

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Duchesne County, Utah	14	3:30-5 p. m.	880		$15,000	Hail	Damage principally to alfalfa seed crop; path 4 miles long.	Official, U. S. Weather Bureau.
Cloverdale, N. Mex	14	2 p. m.	1,760			Heavy hail	Corn stripped; no other damage reported	Do.
Neola, Utah	15	4:30 p. m.			2,500	Hail	Alfalfa seed crop damaged	Do.
Colony, Wyo	15	6:30-7:30 p. m.	2 mi.			Heavy hail	1 to 6 inches of hail; sheep, game birds, and rabbits killed; windows broken; most crops destroyed.	Do.
Ballantine, Mont., eastward across Bighorn River.	15					Hail	Extensive crop damage; path 25 to 30 miles long.	Do.
Sturgis, S, Dak	15	8 p. m.				Wind, rain, and hail.	Roof of garage practically destroyed, windows and street lamps broken, autos damaged.	Daily Journal (Rapid City, S. Dak.).
Rattlesnake Buttes, Colo	16	5:30 p. m.				Heavy hail	Large stones in areas injured cattle; a number of fields of beans and some corn destroyed; roofs riddled and windows shattered.	Official, U. S. Weather Bureau.
Porter, N. Mex	16	6 p. m.	1-2 mi.		15,000	Moderate to heavy hail.	Cotton and broom corn damaged	Do.
Northwest of Alzada, Mont., to South Dakota line.	17	6-7 p. m.	50			Tornado and hail	Damage limited to a few small buildings	Do.
Harrisburg, Pa. (10 mi. ne. of).	17				5,000	Thunderstorm	Barn and contents destroyed by lightning	Do.
Oriva, Wyo	18					Heavy hail	Much damage to unharvested crops	Do.
Southern Wisconsin and Michigan, central Iowa and northern Illinois.	18-19			3		Wind and floods	Thousands of acres inundated; crops beaten, and in many places completely destroyed; communication demoralized; shipping on Lake Michigan held up; heaviest loss in Iowa.	Official U. S. Weather Bureau; Wisconsin State Journal (Madison); Grand Haven Daily Tribune (Mich.).
Conklin Center and Kirkwood, N. Y.	20	P. m.	550			Tornado	5 buildings demolished, several cattle killed, and one person seriously injured.	Official, U. S. Weather Bureau.
Toledo, Ohio	20				20,000	Thunderstorm	Lightning struck generator house on the T. & O. C. Railroad docks, causing fire.	Do.
Knowles, Wyo	20					Heavy hail	Corn badly damaged	Do.
Osseo, Wis	21	4 p. m.			100,000	Squall	Much damage to buildings and crops	Do.
Central, Ind	22			1		Wind and rain	Crops and property damaged	Evansville Courrier (Ind.).
Poplar, Mont. (9 mi. se. of)	22		880			Hail	Farms considerably damaged	Official, U. S. Weather Bureau.
Ashland County, Ohio	22	P. m.		1		Wind and electrical.	Amount of damage not reported	Do.
Smith County, Kans	22	2:30 p. m.				Hail	Many fields of corn totally destroyed; foliage beaten from trees.	Do.
Plymouth County, Iowa	23	8:15 a. m.	2.5 mi.		80,000	do	Heavy crop loss, much glass broken and poultry killed.	Do.
Pottawattamie County, Iowa.	23	11:30 a. m.				do	Crop damage heavy	Do.
Hamilton County, Iowa	23	9 p. m.	4 mi.			do	Considerable damage to corn, truck, and glass	Do.
Walnut, Iowa	23	10 p. m.			20,000	do	Considerable crop damage reported	Do.
Northwestern Missouri	23	P. m.			10,000	do	Damage was principally to corn, but a few windows were broken and outhouses damaged.	Do.
Galesburg (near), Ill	24	8:30 p. m.	1,760			do	Leaves stripped from corn	Do.
St. Patrick, La. (and vicinity)	24	3:10 p. m.		9	5,000	Tornado	Church demolished and other buildings damaged; 20 persons injured.	Do.
Clinton, Ark	24	3 p. m.	1,320			Moderate hail	Corn stripped and cotton considerably damaged	Do.
Wright County, Iowa (Troy Township).	24	9 a. m.				Hail	Loss of crops 30 per cent	Do.
Border of Harrison and Lewis Counties, W. Va.	24-25			2		Thunderstorm	Considerable damage at Lost Creek and Janelew; several houses, 1 railway, and 5 highway bridges washed from foundations; crops generally destroyed.	Do.
Miami, N. Mex	25	11 a. m.	1.5 mi.			Moderate hail	Small grain in fields damaged 25 per cent to total	Do.
Atlantic seaboard	25-26			2		Tropical hurricane	Shipping delayed; small cottages at beaches damaged; several small boats missing, many lives endangered; much damage on coast and inland in Rhode Island.	Official U. S. Weather Bureau; Virginian Pilot (Norfolk, Va.); Evening Bulletin (Providence); Boston Herald.
Helena (near), Mont	28	6:30 p. m.				Wind	Wires and trees blown down	Official, U. S. Weather Bureau.
Marion County, Ala	29	5 p. m.				Heavy hail	Cotton severely damaged	Do.

STORMS AND WEATHER WARNINGS

WASHINGTON FORECAST DISTRICT

During the latter half of the month two tropical disturbances reached the Lesser Antilles from the region to the eastward. The first of these was centered between Dominica and St. Lucia the morning of the 17th and the second a short distance northeast of Dominica the evening of the 27th. The tracks of these two disturbances were almost parallel for about 800 miles, both moving almost directly northwestward from the Lesser Antilles, the first at the rate of approximately 270 miles and the other 200 miles a day. The former continued to move in a northwesterly direction until it reached latitude 28° N. and longitude 75° W. It then moved slowly in a westerly direction for 48 hours, after which it turned abruptly and moved north-northeastward with rapidly increasing speed and its course gradually changed toward the northeast. (See Chart II.) Ten and one-half days after this tropical disturbance had appeared over the Lesser Antilles, its center was between Belle Isle and Fogo, Newfoundland, while eight and one-half days after the second disturbance was first noted its center was in the same location. However, after reaching latitude 25° N. the course of the latter was almost due north for 36 hours, then north-northeast to western Newfoundland, the paths of the two storms gradually converging.

The first tropical disturbance was of only slight intensity in the region of the Lesser Antilles and of moderate intensity when its center passed between Porto Rico and the Virgin Islands during the evening of the 18th. It increased gradually, however, both in intensity and size after passing to the north of Porto Rico and within three days, when its center was in about latitude 27° 30′ N. and longitude 74° 30′ W., the winds near the center had increased to hurricane force. At this time the storm was beginning to recurve to the northward into a shallow trough of low pressure that was moving eastward from the middle and north Atlantic coast, but its path to the northward was blocked by an anticyclone that moved eastward from the Upper Lake region to the North Atlantic States during the 20th-22d. The influence of

this anticyclone extended southward to the vicinity of the hurricane and changed the direction of movement of the air in the intermediate and higher levels toward the west. However, the air movement was slight in the levels that control the direction of movement of tropical cyclones, and the westward progress was quite slow. This condition continued for about two days, although pressure gradually decreased over the Middle Atlantic and North Atlantic States. By the evening of the 24th a trough of low pressure, moving eastward, extended from western Quebec southwestward to the east Gulf States, and as is always the case with such troughs, the wind aloft changed to southerly some distance to the eastward with the result that the tropical storm began to move northward, and a little later to the north-northeastward. Hurricane winds and mountainous seas were reported from vessels within the storm area, especially during the 23d–25th, with barometer readings below 29 inches, the lowest reported being 28.67 inches.

The rate of movement of this storm was very rapid after the morning of the 25th, at which time its center was in latitude 26° N. and longitude 76° W. The center passed a short distance east of Cape Hatteras about 9 p. m. of the 25th and immediately east of Nantucket, Mass., about 1 p. m. the following day. The highest wind velocity reported from a land station was 72 miles an hour from the northwest at Cape Hatteras. A number of vessels were somewhat damaged by the hurricane winds and mountainous waves off the south Atlantic and middle Atlantic coasts and along the trans-Atlantic steamer lanes, especially between longitudes 65° and 70° W. The S. S. *Arabic* was hard hit by the hurricane and several passengers were injured. No reports have been received of material damage along the Atlantic coast.

Advisory warnings of the location, intensity, and progress of this, one of the greatest hurricanes in both intensity and extent ever experienced off the Atlantic coast, were issued twice daily from the time the disturbance was first noted. Timely warnings were broadcast by radio of the probable increase in intensity of this storm after it passed Porto Rico and vessels bound for the regions traversed by the hurricane were advised to exercise caution. The first storm warnings in connection with this storm were displayed on the 22d from Cape Hatteras to Jupiter Inlet, and when it became evident that the storm was moving westward the warnings were extended southward to Miami. On the morning of the 25th, shortly after the hurricane had recurved to the northward, storm warnings were extended north of Cape Hatteras to the Virginia Capes, and at 6 p. m. to Atlantic City. Hurricane warnings were ordered displayed at 4 p. m. from Beaufort, N. C., to Cape Henry. Northeast storm warnings were displayed as far north as Boston at 9:30 p. m. of the 25th and were extended to Eastport, Me., on the following morning.

The second tropical disturbance evidently developed much farther east than the first, insamuch as it was already a storm of considerable intensity when it appeared near Dominica on the 27th. By the time it reached the Virgin Islands it had attained hurricane intensity. The barometer fell to 29 inches at St. Thomas at 3 a. m. of the 29th and great damage was done by the storm in these islands. A number of lives were lost, hundreds of houses were destroyed and thousands damaged, and much damage was done to crops. So great were the losses in the Virgin Islands that appeal was made to the American Red Cross for substantial aid.

After this storm passed over the Virgin Islands few vessel reports were received from its vicinity and as its center passed about 150 miles east of Turks Island and the same distance west of Bermuda the barometer did not fall below 29.78 inches at either place; but Bermuda reported a wind velocity of 36 miles an hour from the southwest the morning of September 3. The S. S. *Ponce* reported a barometer reading of 29.16 inches and a southwest wind of force 9 (Beaufort scale) on the 2d in latitude 28° N. and longitude 68° 40′ W. This storm was of much smaller diameter and less intensity than the previous hurricane and since the number of vessels in the part of the ocean over which it passed is usually quite small, it is not surprising that few reports were received by radio from vessels near the hurricane center. Advisory warnings regarding the approximate location, direction of movement, and intensity of this storm were issued twice daily, and vessels bound for the regions affected were advised to exercise caution.

No storm warnings were issued during the month, except those previously referred to in connection with the first tropical storm.—*C. L. Mitchell.*

CHICAGO FORECAST DISTRICT

The weather conditions during the month were rather unusual in the Chicago Forecast District. It was unseasonably cool most of the time in the north and central portions of the district, especially during the first two decades, but at the same time it was rather warm in the southwestern portion. At the close of the month a warm wave had become general, as it was reaching eastward over the Middle States.

The rainfall, too, was unusual in its distribution, being heavy to excessive in the eastern and east-central portions of the district, but somewhat deficient in the more westerly portions. The rains were chiefly in connection with thunderstorms, and the amounts extraordinary at some points in the Middle States, especially in portions of Illinois, Wisconsin, Minnesota, Iowa, and Missouri.

With few exceptions, warnings were not necessary and those issued were confined to small-craft warnings on the Great Lakes and frost warnings to the cranberry marshes of Wisconsin.

The warnings in the interests of the cranberry growers were highly satisfactory, as usual. The following letter, under date of August 14, was received from the Cranberry Growers Association of Wisconsin:

> Members of this association held their annual summer session at the pavilion near Nehoosa last Tuesday, August 12, at which time a most hearty and unanimous vote of thanks was accorded you for the invaluable assistance you have rendered the cranberry growers in the past by sending out the weather reports and warnings to the various districts.
>
> It is a favor of untold value to every grower, and I assure you is very much appreciated by all.

—*H. J. Cox.*

NEW ORLEANS FORECAST DISTRICT

The characteristic summer HIGH of the South Atlantic States, with pressure diminishing gradually westward, attended by daytime showers in the east Gulf States and on the middle Gulf coast, was charted on only a few days during this month. High pressure over the northeastern States was a more frequent condition and at other times the pressure was slightly higher over the Lower Mississippi Valley than on the South Atlantic coast. This distribution of pressure does not favor converging winds in Gulf coast sections and one result was the abnormally hot, dry weather prevailing in the eastern and southern portions of this forecast district during

August, 1924. The greatest deficiency of precipitation occurred on the immediate coast of Texas, with only a "trace" of rain at Galveston and 0.02 inch at Corpus Christi. In general features of the pressure distribution over the Atlantic and Gulf States and of rainfall on the Texas coast, this August resembles August, 1902, when there was no rain at Galveston and only a "trace" at Corpus Christi; but August, 1902, on the whole, was drier in the interior of Texas than August, 1924.

No high winds occurred and no warnings were issued. —*R. A. Dyke.*

DENVER FORECAST DISTRICT

The distribution, direction, and velocity of movement, and intensity of areas of high and low atmospheric pressure during August were such as to fail to produce the usual precipitation from thunderstorms in the Denver district, except in western Colorado, where precipitation was normal. Temperatures were generally above normal over the district. The deficiency in precipitation in eastern Colorado was most pronounced, the month being one of the driest on record in that section. High-pressure areas, which in conjunction with Arizona low areas, are effective usually in producing summer thunderstorms in eastern Colorado, either were too feeble, too rapid in movement, or following a course too far northward to cause normal showers. As precipitation had been deficient throughout the summer, the dryness became acute during the latter half of the month.

On the evening of the 18th a low-pressure area, moving slowly over Colorado, indicated increasing westerly to northerly winds, very low humidity and high temperatures in the eastern portion of the State, and consequently forest officials were warned of the expected increase in the already high fire hazard. As low pressure continued over this region and developed somewhat in intensity, similar warnings were issued on the evenings of the 19th and 20th. During the period covered by these warnings the relative humidity at Denver was very low, the lowest observed being 7 per cent and the highest temperature was 91°, while at the elevated lookout station on Devil's Head, within the forested region, the wind movement was high and a maximum velocity of 40 miles an hour was recorded at one observation.

Owing to the demand for the information and the graveness of the situation, advice was published, beginning on the 21st, each morning during the remainder of the month relative to the fire hazard as affected by the meteorological conditions expected. Appreciation was expressed for the service rendered by the Weather Bureau, as it proved of value in coping with forest fires.

No other warnings were required.—*Lawrence C. Fisher.*

SAN FRANCISCO FORECAST DISTRICT

The outstanding feature of the weather in this district during August, 1924, was a small storm which appeared near Sitka on the 16th, moved southward along the coast on the 17th, and passed inland over British Columbia, near the international boundary, on the 18th. It gave light but general rain over the northern portion of this district and extended southward into the extreme northern counties of California. The rain greatly relieved the dangerous forest-fire condition in the areas in which it fell.

During the first decade the temperature was nearly normal throughout the district. In the first three days of the second decade there was a marked warming up in the northern portion of the district, which was followed by unsettled and cooler weather from the 16th to the 21st, over the entire district. A marked warm spell accompanied by low humidity prevailed over the interior of the entire district from the 23d to the 28th. On the afternoon of the 27th the record for high temperature in August was broken at Fresno, where the thermometer reached 110°.

The fire-weather hazard was high in the interior sections during the greater portion of the month and advices were broadcast twice daily covering this condition. No other warnings were required.—*G. W. Willson.*

RIVERS AND FLOODS

By H. C. Frankenfield, Meteorologist

Aside from that in the Illinois River, no extensive floods occurred in the principal rivers of the country during August, 1924. Considerable damage to farms, rural communities, highways, and railroad property, and some loss of life occurred, however, from local floods which followed unusually heavy rainfall during the first three weeks of the month over eastern Iowa, southern Wisconsin, and northern Illinois. In the latter State the major portion of the damage—principally to harvested crops, livestock, and highway and railroad bridges—occurred in Henry, Knox, Mercer, and Stark Counties, following the rains of the 19th and 20th.

In east-central Iowa during the same period local damage of a similar character was considerable and two fatalities occurred.

In southern Wisconsin, following the very excessive rains of August 3–6, the highest flood of record and nine fatalities occurred in the Milwaukee River Valley, and losses and damage in this and other sections was estimated at upward of $1,000,000. In the Milwaukee River the current was so swift that large steamers were compelled to anchor outside the harbor, some being delayed for three days. A moderate repetition of the conditions occurred with one fatality between Lake Winnebago and Lake Michigan following the rains between the 19th and 21st.

The more general flood in the Illinois River, occurring less than two weeks after the subsidence of the flood of late June–July, was brought about by the same general rains of August 19–21. This flood was chiefly remarkable for its time of occurrence, as high stages in the late summer are rare in the Illinois River. Stages in the upper river were generally somewhat higher than during the late June–July flood; but losses, which in the latter were considerable to crops and in finally preventing late planting, were not materially increased in this respect. Flood warnings were timely and well verified. The property losses were enormous when the limited territory involved is considered. Detailed statements could not be obtained, but newspaper estimates were as high as $3,000,000, mainly along the smaller tributary streams, with railroads probably the greatest sufferers.

The same general rainfall conditions also caused a local flood in the Mississippi River district from the mouth of the Des Moines to the mouth of the Illinois River. Warnings were issued on August 23 and very little damage was done, about $5,000 in crops, as the lowlands had been overflowed since early July.

On August 11 heavy local mountain rains caused a severe flood in the Galisteo River, a tributary of the Rio Grande, in northern New Mexico. The town of Lamy was inundated, and the losses in the town and adjacent country were probably as much as $500,000.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC DRAINAGE					
Cape Fear:	*Feet*			*Feet*	
Elizabethtown, N. C	22	5	6	22.7	6
MISSISSIPPI DRAINAGE					
Mississippi:					
Quincy, Ill	14	26	27	14.1	26
Hannibal, Mo	13	24	29	14.3	27
Louisiana, Mo	12	25	29	13.2	12
Illinois:					
Morris, Ill	13	9	13	18.2	10
Peru, Ill	14	8	(1)	19.8	11
Henry, Ill	7	8	(1)	13.7	23–24
Peoria, Ill	16	10	(1)	21.0	24
Havana, Ill	14	12	(1)	19.0	25
Beardstown, Ill	12	(2)	(1)	19.1	28–29
Pearl, Ill	12	24	(1)	15.7	30
Neosho:					
Oswego, Kans	17	7	7	17.3	7
North Canadian:					
Woodward, Okla	4	14	14	4.5	14

[1] Continued at end of month.
[2] Continued from last month.

MEAN LAKE LEVELS DURING AUGUST, 1924

By UNITED STATES LAKE SURVEY

[Detroit, Mich., Sept. 4, 1924]

The following data are reported in the "Notice to Mariners" of the above date:

Data	Lakes [1]			
	Superior	Michigan and Huron	Erie	Ontario
Mean level during August, 1924:	*Feet*	*Feet*	*Feet*	*Feet*
Above mean sea level at New York	601.65	579.62	572.16	246.04
Above or below—				
Mean stage of July, 1924	+0.26	+0.10	−0.29	−0.17
Mean stage of August, 1923	−0.34	−0.13	+0.47	+0.63
Average stage for August last 10 years	−1.00	−1.19	−0.46	−0.34
Highest recorded August stage	−2.28	−3.89	−1.95	−2.22
Lowest recorded August stage	+0.05	−0.13	+0.78	+1.69
Average relation of the August level to—				
July level	----------	−0.1	−0.2	−0.3
September level	----------	+0.2	+0.2	+0.4

[1] Lake St. Clair's level: In August, 1924, 574.83 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS—AUGUST, 1924

By J. B. KINCER

General summary.—The first 10 days of August were' on the whole, rather favorable for farm interests in Central and Northern States east of the Rocky Mountains. There was considerable rainfall in some sections where drought had prevailed, especially in the western Great Plains, parts of the Ohio Valley, and middle Atlantic area, and the increased moisture was beneficial for growing crops. It continued too cool for warm-weather crops, however, in the Central-Northern States, while frequent rainfall in that area caused considerable interruption to farm work. It had become dry in the south Atlantic districts, and drought continued in the central and west Gulf areas, where all crops suffered severely. Fine growing weather prevailed in the lower Missouri Valley and in the southern Great Plains.

The second decade of the month was too cool for best growth in the interior States; decidedly so in most of the Ohio Valley. Crops made fairly good growth, however, in the central Great Plains and lower Missouri Valley, where there was sufficient moisture and an abundance of sunshine. They showed material improvement during this period in the Middle and North Atlantic States, by reason of the increased soil moisture, but at the same time it continued generally dry in the South.

The last decade of the month brought much warmer weather to the interior valleys and Northern States, which was very beneficial to growing crops, though more moisture was needed locally. Late vegetation showed continued improvement in the Northwestern States as a result of better growing conditions, but at the close of the month it was again getting dry. Severe drought persisted in the Great Basin, and droughty conditions in the South were intensified by the continued absence of moisture. Most crops suffered, especially gardens, truck, and late corn.

Wheat.—Spring wheat matured rapidly during the first few days of the month under generally favorable weather conditions. There was considerable infection of wheat by black stem rust in North Dakota, but the bulk of the crop was too near maturity for material damage. Harvest made good progress and was rushed in North Dakota to avoid rust damage. Fairly good advance was made in threshing winter wheat during the first half of the month, although there was some delay by frequent rains in the upper Mississippi Valley. The last half was rather unfavorable for threshing in the western Lake region, the upper Mississippi Valley, and northern Great Plains, because of frequent rainfall, with considerable damage reported to grain in shock.

Corn.—Conditions, in general, were rather unfavorable for corn during the first three weeks of the month, because of persistently cool weather from the central valley States northward. Growth was good, however, in the Plains States and fairly satisfactory in the lower Missouri Valley. In the South, late corn suffered severely from the dry weather. Corn was 10 days to as much as 3 weeks late in most of the principal producing area, and warm weather was badly needed to hasten maturity. The last 10 days of the month, however, had generally warmer weather throughout the central and northern portions of the country, and the corn crop responded nicely to the improved temperature conditions. Splendid progress toward maturity was reported in the central Great Plains States. There was some deterioration in Ohio and parts of Kentucky because of insufficient moisture.

Cotton.—There was considerable rainfall the first part of the month in the northern portions of the Cotton Belt, including northern and northwestern Texas, and progress of the crop was mostly fair to very good in those regions. Moisture was needed in other portions of the belt where the advance was less satisfactory. During the second decade rainfall was of a local character, and moisture continued insufficient in many sections, though there were beneficial rains in parts of the Mississippi Valley States, and good local showers in the western portion of the belt.

The progress and condition of cotton continued very good in the extreme western and northwestern portions of Texas, but were generally poor elsewhere because of the drought, with bolls small in the dry areas and opening prematurely. There were sufficient showers to be beneficial in Oklahoma the latter part of the month, but rain was generally needed, with progress of cotton ranging from fair in the north to poor in the south. Dryness prevented satisfactory growth in the central States of the belt, with some deterioration reported. The drought was partially relieved by irregular showers in Georgia the latter part of the month, but most sections continued dry and cotton showed further deterioration, while the drough

was intensified in the Carolinas, especially South Carolina, with increased shedding and progressive deterioration in most places.

Potatoes and truck.—The generally cool weather and mostly ample soil moisture made conditions favorable for potatoes in Central and Northern States, though it was somewhat too dry in the upper Ohio Valley. Late truck was unfavorably affected by dry weather throughout the Southern States, but showed improvement in the middle Atlantic area by reason of better moisture conditions.

Pastures and livestock.—Pastures were poor throughout the month in the Southern States, but improved in the middle and north Atlantic areas, and were mostly in good condition for the season in the central valleys and Great Plains. Rain was needed for the range in New Mexico and stock water was scarce in parts of the central Rocky Mountain area. Ranges and pastures suffered for moisture in the more western States, but livestock did very well generally.

WEATHER DURING THE CROP-GROWING SEASON OF 1924

The weather during the crop-growing season of 1924 in Central and Northern States east of the Rocky Mountains was characterized, on the whole, by coolness and, during much of the time, by frequent rains. There was at no time a serious lack of moisture in these sections, although more was needed during a part of the season in some local areas, particularly in portions of the Ohio Valley and in the Middle Atlantic States. The season was, in general, too cool for good growth of warm-weather crops, but those preferring cool weather, such as the small grains, potatoes, and hardy truck, did well. There was too much rain in many localities which interfered considerably with farm operations, particularly in the upper Mississippi and lower Missouri Valleys, and crops were generally late in maturing, especially corn.

Rainfall was mostly above normal, with frequently too much moisture, in the Southeast until August, when droughty weather prevailed and all vegetation suffered considerably. Temperatures during the three summer months ranged above normal in this area. In the central and west Gulf sections the season was characterized by dryness and temperatures above the normal. The most serious deficiency in moisture anywhere east of the Rocky Mountains occurred in this area. While limited areas in the principal agricultural sections east of the Rocky Mountains had insufficient moisture during the season, no extensive and damaging drought prevailed, except in the west Gulf States. West of the Rocky Mountains, however, the entire season was characterized by deficient moisture, and most unirrigated crops suffered. High temperatures and the absence of the usual amount of rainfall demanded heavy irrigation, with resulting inadequate water supply in many districts.

Small grains.—The weather and soil conditions during the fall of 1923 were favorable for seeding, germination, and early growth of fall-sown grains. Moisture was unusually abundant in the western portion of the Winter Wheat Belt, and the mild fall was favorable for the establishment of a good root system before winter set in. Consequently, the wheat crop came through a rather severe winter in the western portion of the belt with but little harm. There was considerable damage by winterkilling, however, in parts of the Ohio Valley States. The spring months were cool, moist, and favorable for wheat, while unusually good weather for filling and ripening prevailed, which largely offset the effect of the winter freezes in the eastern portion of the belt.

Spring wheat got a rather poor start, because of the late season, but the cool, moist weather later favorably affected development in the principal producing areas and a generally good crop was harvested. There was considerable infection by black stem rust in some sections, especially in North Dakota, but the disease developed too late to materially reduce the yield. West of the Rocky Mountains both spring and winter wheat were seriously harmed by insufficient moisture. Oat seeding was greatly delayed in the North, because of wet weather, but later this crop showed steady improvement, due to favorable temperature and moisture conditions, and a satisfactory yield was obtained in most districts.

Corn.—The weather was decidedly unfavorable for planting corn and for germination during May in the principal producing States, being much too cool generally and too wet from the Mississippi Valley eastward. Planting was much delayed, so that considerable corn remained unplanted until after the 10th of June. In the Great Plains the weather permitted seeding about the usual date. The summer months were too cool and, in many places, too wet for corn from the upper Mississippi Valley eastward, resulting in poor cultivation and much complaint of grassy fields. Conditions were more favorable in the central Great Plains and lower Missouri Valley, and by the end of August a good to excellent early crop had matured in Oklahoma and was fast approaching maturity in eastern Kansas. In the upper Mississippi and Ohio Valleys corn was generally two to three weeks late.

Cotton.—The cool, wet weather during March was unfavorable for cotton planting and at the end of that month seeding was very backward, and the germination of the early seeded in more southern districts was poor. April was more favorable and planting made fairly good progress, although it continued too cool and wet in the northern portion of the belt. May was too cool generally, with too much rain in northern districts; the month, on the whole, was decidedly unfavorable.

Early in June there was a reaction to higher temperatures and that month, in general, had moderately warm weather, with less rainfall, which brought improvement to cotton, although the hot, dry weather the latter part of the month was unfavorable in the west Gulf section. The first half of July had too much rain in the eastern portion of the belt, but the latter half was more favorable. Drought continued from the lower Mississippi Valley westward and rainfall was badly needed. August had deficient rainfall throughout the belt, except in local areas, principally in the northern portion.

Truck, pastures, and miscellaneous crops.—The season was favorable for potatoes, hardy truck, and pastures quite generally east of the Rocky Mountains, except in the central and west Gulf areas, but was less favorable for sweet potatoes in the Southeast. It was rather unfavorable for tobacco and peanuts. Sugar beets grew well, but there was insufficient moisture in the Gulf sections for sugar cane. In central and eastern districts there was very little spring frost damage to fruit, but in the more northwestern States this crop suffered serious harm from frost.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation, by sections, August, 1924

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	° F.	° F.		° F.			° F.		In.	In.		In.		In.
Alabama	81.9	+2.2	4 stations	104	[2] 28	Valley Head	52	12	2.91	−1.85	Dadeville	6.19	Fayette	0.46
Alaska (July)	54.2	−1.9	Fort Yukon	88	18	White Mountain	16	3	4.71	+0.84	Speel River	13.51	Broad Pass	0.53
Arizona	79.9	+1.4	Maricopa	118	[2] 25	2 stations	34	21	0.82	−1.48	Baboquivari	3.39	11 stations	0.00
Arkansas	82.2	+3.2	Pine Bluff	108	3	Corning	43	15	2.40	−1.43	Heber Springs	6.46	Whitecliffs	T.
California	70.8	−1.7	Greenland Ranch	124	27	Summit	28	2	0.07	−0.03	Upper Mattole	1.45	147 stations	0.00
Colorado	65.4	+0.4	Lamar	107	2	3 stations	23	[2] 21	0.71	−1.37	Mesa Verde Park	4.20	Terminal Dam	0.00
Florida	82.8	+1.5	Carrabelle	103	22	2 stations	62	[2] 13	4.26	−2.54	Homestead	9.33	Sand Key	1.32
Georgia	81.8	+2.3	Lisbon	107	28	3 stations	53	[2] 2	2.47	−3.05	Tallapoosa	5.52	Carlton	0.36
Hawaii	74.3	−0.4	Mahukona	94	20	Waimea	50	[2] 4	4.81	−2.19	Puu Kukui (upper)	25.00	8 stations	0.00
Idaho	65.0	−0.9	2 stations	109	27	Stanley	12	[2] 21	0.50	−0.13	Porthill	2.61	11 stations	0.00
Illinois	74.1	0.0	do	103	[2] 4	Windsor	41	14	5.14	+1.82	Galva	13.51	Carmi	0.56
Indiana	73.2	−0.1	Vincennes	102	30	2 stations	43	14	3.71	+0.45	Rockville	8.68	Mount Vernon	0.60
Iowa	71.7	0.0	3 stations	100	[2] 21	Hampton	40	[2] 11	5.35	+1.91	Iowa Falls	12.38	Glenwood	1.90
Kansas	78.8	+1.4	Alton	111	3	St. Francis	49	16	4.09	+0.92	Fort Riley	12.29	Hill City	0.42
Kentucky	76.4	+0.8	Franklin	103	21	Farmers	43	15	3.04	−0.67	St. John	7.17	Bowling Green No. 2.	0.32
Louisiana	84.3	+2.7	Dodson	107	[2] 4	Kelly (near)	57	27	2.30	−2.98	Grand Cane	6.70	Ruston	0.20
Maryland-Delaware	73.4	0.0	2 stations	103	31	2 stations	37	[2] 15	4.07	−0.35	Ferry Landing, Md.	7.44	Crisfield, Md	1.09
Michigan	65.3	−1.0	Monroe	99	31	Ewen	29	18	3.56	+0.77	Calumet	7.97	Charlotte	0.59
Minnesota	65.4	−1.3	Pipestone	99	26	Grand Rapids	30	17	4.90	+1.94	Waseca	11.89	Thief River Falls	1.31
Mississippi	83.3	+2.9	Columbus	107	29	Scott	53	26	1.80	−2.56	Corinth	6.22	Moorhead	0.26
Missouri	77.2	+1.2	Caruthersville	106	[2] 4	Louisiana	48	12	4.14	+0.46	Lebanon	9.51	Warrensburg	0.99
Montana	63.1	−1.6	Roy	110	27	Pleasant Valley	20	31	1.00	−0.25	Springbrook	5.04	Crow Agency	0.00
Nebraska	73.7	+0.9	Falls City	107	26	Gordon	33	22	2.15	−0.65	Tekamah	6.70	Hull (near)	0.28
Nevada	70.5	−0.7	Logandale	114	26	Quinn River Ranch	28	22	0.13	−0.29	Tonopah	1.72	14 stations	0.00
New England	67.3	+0.6	2 stations	98	7	Cavendish, Vt	31	2	4.66	+0.89	Blue Hill, Mass	8.00	St.Johnsbury, Vt	1.33
New Jersey	71.9	0.0	Indian Mills	102	6	Runyon	38	19	4.44	−0.47	Runyon	9.48	Charlotteburg	1.82
New Mexico	72.1	+1.0	Gage	109	8	2 stations	28	[2] 21	1.60	−0.78	Hayden	5.60	2 stations	0.00
New York	67.4	−0.4	2 stations	100	[2] 6	4 stations	34	[2] 1	3.65	−0.12	New York City	6.99	Lauterbrunnen	0.50
North Carolina	76.2	+1.1	do	104	28	Mount Mitchell	42	14	3.97	−1.58	Beaufort	11.85	Monroe	0.15
North Dakota	63.8	−1.6	Dickinson	102	28	Hansboro	28	16	1.65	−0.63	Larimore	3.96	Richardton	0.07
Ohio	72.0	+0.2	4 stations	101	[2] 5	Canfield	38	19	2.12	−1.34	Dam No. 28	5.34	Ohio State University.	0.16
Oklahoma	83.6	+3.0	2 stations	109	24	Kenton	51	27	2.42	−0.93	Miami	6.82	Holdenville	0.40
Oregon	65.2	−0.6	3 stations	105	[2] 11	Lapine	20	[2] 30	0.58	+0.12	Astoria	2.23	2 stations	T.
Pennsylvania	70.1	0.0	Phoenixville	102	[2] 6	West Bingham	31	2	3.78	−0.79	Narberth	7.54	Beaver Dam	1.48
Porto Rico	78.8	−0.3	Arecibo	98	[2] 9	Utuado	57	4	9.17	+1.82	Comerio Falls	17.95	Camuy	1.74
South Carolina	80.4	+1.6	Calhoun Falls	105	28	2 stations	53	16	2.86	−3.14	Charleston	8.28	Catawba	1.18
South Dakota	69.7	−0.2	2 stations	105	28	do	33	31	2.44	−0.03	Armour	7.88	Ardmore	0.23
Tennessee	78.6	+2.0	3 stations	104	[2] 22	Crossville	44	15	2.44	−1.68	Bluff City	6.95	McGhee	0.34
Texas	85.6	+3.0	2 stations	112	[2] 12	Dalhart	55	22	1.32	−1.28	Garden City	7.17	25 stations	0.00
Utah	69.5	−0.1	St. George	108	[2] 27	2 stations	27	[2] 19	0.46	−0.45	Fishlake ranger station.	2.37	6 stations	0.00
Virginia	74.4	+0.1	Leeds Manor	107	6	Burkes Garden	40	15	4.33	−0.09	Newport News	9.21	Quantico	0.71
Washington	65.5	−0.8	Wahluke	105	12	Deer Park	29	31	0.91	+0.30	Quinault	2.54	Lakeside	0.00
West Virginia	71.7	+0.1	2 stations	104	6	Terra Alta	34	15	4.63	+0.27	Horner	9.34	Martinsburg	0.69
Wisconsin	65.6	−1.3	Prairie du Chien	95	26	Long Lake	29	18	7.29	+4.11	West Bend	13.17	Marinette	3.37
Wyoming	63.4	−0.1	3 stations	101	[2] 2	South Pass City	20	22	0.43	−0.65	Colony	3.61	5 stations	0.00

[1] For description of tables and charts, see REVIEW, Ja nuary, 1924, pp. 56-57.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, August, 1924*

Districts and stations	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Departure from normal	Days with 0.01, or more	Wind: Total movement	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
New England							67.9	+0.5										79	4.43	+0.6										4.9		
Eastport	76	67	85	29.85	29.93	−.03	60.3	−0.4	81	30	68	48	17	52	23	56	54	84	4.79	+1.5	11	5,398	s.	44	s.	4	8	6	17	6.7	0.0	0.0
Greenville, Me	1,070	6	----	28.82	29.97	----	63.6	----	85	6	74	40	3	54	37	----	----	----	2.34	----	14	----	se.	----	----	----	11	10	10	----	0.0	0.0
Portland, Me	103	82	117	29.86	29.98	.00	66.4	0.0	91	30	74	51	2	59	25	61	57	76	3.36	−0.2	9	5,250	s.	38	w.	7	15	6	10	4.8	0.0	0.0
Concord	288	70	79	29.66	29.96	−.02	68.0	+1.2	95	7	80	42	3	56	38	----	----	----	2.67	−1.1	8	2,965	nw.	22	sw.	7	17	7	7	4.2	0.0	0.0
Burlington	404	11	48	29.52	29.95	−.02	66.8	−1.1	88	30	76	45	3	58	32	----	----	----	2.37	−1.6	11	6,841	s.	36	s.	4	7	13	11	5.7	0.0	0.0
Northfield	876	12	60	29.04	29.98	.00	63.1	−0.3	89	31	76	37	3	51	39	60	59	86	2.23	−1.7	13	4,504	s.	27	sw.	27	8	13	10	5.6	0.0	0.0
Boston	125	115	188	29.84	29.97	−.02	71.8	+1.9	98	7	80	56	19	64	26	64	60	72	6.86	+2.8	9	6,409	sw.	44	n.	26	11	11	9	5.1	0.0	0.0
Nantucket	12	14	90	29.96	29.97	−.02	68.2	+0.4	83	9	74	57	23	62	19	64	62	86	4.74	+1.7	9	9,812	sw.	60	nw.	26	15	8	8	4.5	0.0	0.0
Block Island	26	11	46	29.95	29.98	−.01	68.8	+0.3	84	9	75	57	19	63	18	64	63	85	6.23	+2.8	9	9,830	sw.	78	n.	26	14	8	9	4.0	0.0	0.0
Providence	160	215	251	29.81	29.98	−.01	71.2	+0.2	94	7	81	54	19	62	29	63	59	71	5.39	+1.3	8	4,846	sw	50	n.	26	15	11	5	4.3	0.0	0.0
Hartford	159	122	140	29.81	29.98	−.01	71.4	+2.5	96	7	81	51	3	62	32	----	----	----	4.95	+0.4	11	----	s.	----	----	----	15	10	6	3.9	0.0	0.0
New Haven	106	74	153	29.87	29.98	−.01	71.3	+1.0	92	7	80	55	2	63	27	64	61	72	5.15	+0.2	9	6,147	sw.	44	ne.	26	13	10	8	4.6	0.0	0.0
Middle Atlantic States							73.4	+0.1										75	4.58	0.0										4.5		
Albany	97	102	115	29.87	29.97	−.01	70.8	0.0	93	7	81	52	19	61	28	64	60	74	3.74	−0.2	11	4,938	s.	29	s.	20	15	9	7	4.2	0.0	0.0
Binghamton	871	10	84	29.06	29.97	−.02	68.2	+0.2	92	31	80	44	19	57	37	----	----	----	5.26	+1.9	13	3,264	sw.	22	nw.	20	6	17	8	5.5	0.0	0.0
New York	314	414	454	29.66	29.98	−.02	72.9	−0.2	93	7	80	56	19	65	23	65	62	71	6.99	+2.5	8	10,671	sw.	56	w.	7	10	13	8	5.3	0.0	0.0
Harrisburg	374	94	104	29.61	30.00	−.01	73.0	+0.4	97	6	82	52	19	64	30	64	60	67	3.66	−0.6	5	4,137	sw.	27	ne.	12	11	15	5	4.8	0.0	0.0
Philadelphia	114	123	190	29.88	30.00	.00	75.0	+0.2	96	6	83	59	15	67	24	67	63	70	3.77	−0.8	9	6,065	sw.	32	ne.	26	9	11	11	5.6	0.0	0.0
Reading	325	81	98	29.65	29.99	----	73.6	----	97	6	83	53	19	64	28	66	62	72	4.71	+0.2	9	3,057	sw.	21	n.	12	16	10	5	3.8	0.0	0.0
Scranton	805	111	119	29.16	30.01	+.01	69.3	−0.5	93	6	80	44	19	58	32	64	61	79	3.53	−0.7	12	4,527	n.	27	sw.	27	9	17	5	5.0	0.0	0.0
Atlantic City	52	37	172	29.93	29.98	−.02	72.6	+0.1	88	28	78	57	19	67	20	67	65	79	4.38	+0.1	8	10,495	s.	72	n.	26	17	6	8	3.9	0.0	0.0
Cape May	17	13	49	30.01	30.02	+.02	73.6	+0.2	91	28	81	57	15	67	21	68	66	83	3.60	−0.7	7	4,430	s.	23	n.	26	16	9	6	4.0	0.0	0.0
Sandy Hook	22	10	55	29.95	29.98	----	72.8	----	93	7	79	60	19	66	21	66	63	76	5.04	----	5	9,711	s.	58	n.	26	12	13	6	4.5	0.0	0.0
Trenton	190	159	183	29.79	29.98	----	73.4	----	97	6	83	54	19	64	28	66	63	74	5.87	+0.5	8	6,650	sw.	38	n.	26	12	12	7	4.7	0.0	0.0
Baltimore	123	100	113	29.86	29.98	−.03	76.0	+0.5	100	6	84	58	19	68	25	67	63	69	5.22	+1.0	7	3,909	sw.	20	w.	25	13	12	6	4.8	0.0	0.0
Washington	112	62	85	29.88	29.99	−.02	74.8	−0.2	102	6	85	53	19	65	30	67	64	74	5.07	+0.7	10	3,724	s.	20	w.	9	13	11	7	4.6	0.0	0.0
Cape Henry	18	8	54	29.97	29.99	----	77.1	----	100	6	84	64	20	70	25	71	68	78	5.35	−0.8	9	8,884	sw.	68	n.	26	20	8	3	3.5	0.0	0.0
Lynchburg	681	153	188	29.27	30.00	−.02	76.0	+0.4	96	10	86	53	16	66	31	68	65	76	4.80	+0.6	10	3,776	w.	29	n.	25	16	10	5	3.7	0.0	0.0
Norfolk	91	170	205	29.91	30.00	.00	77.6	+0.2	95	10	86	61	19	69	27	70	67	75	4.27	−1.7	6	8,138	s.	50	n.	26	16	11	4	3.9	0.0	0.0
Richmond	144	11	52	29.86	30.00	−.01	76.4	−0.1	97	31	86	53	19	66	28	69	66	76	3.05	−1.4	8	4,629	sw.	26	w.	7	14	10	7	3.9	0.0	0.0
Wytheville	2,304	49	55	27.71	30.01	.00	70.9	+0.4	88	6	82	49	15	60	31	64	62	83	4.63	+0.1	15	3,060	w.	21	sw.	7	10	16	5	4.8	0.0	0.0
South Atlantic States							79.8	+1.6										78	3.79	−2.4										4.2		
Asheville	2,255	70	84	27.74	30.02	.00	73.4	+2.9	89	22	84	55	15	63	27	66	63	82	2.24	−2.3	11	4,117	se.	29	se.	25	13	15	3	4.5	0.0	0.0
Charlotte	779	55	62	29.19	30.00	−.02	80.0	+2.9	98	28	90	57	16	70	30	70	66	69	0.94	−4.6	6	2,671	ne.	25	nw.	7	14	12	5	3.9	0.0	0.0
Hatteras	11	11	50	29.96	29.98	−.02	78.3	+0.3	89	7	84	67	17	73	16	73	71	78	4.44	−1.4	10	8,671	sw.	74	nw.	25	17	7	7	3.7	0.0	0.0
Manteo	12	5	42	----	----	----	77.6	----	96	12	----	58	17	----	32	----	----	----	3.78	----	4	----	s.	----	----	----	20	3	8	----	0.0	0.0
Raleigh	376	103	110	29.61	29.99	−.02	77.7	+0.7	95	11	87	60	15	68	27	70	67	77	5.89	0.0	7	4,752	ne.	42	w.	28	14	13	4	4.4	0.0	0.0
Wilmington	78	81	91	29.92	30.00	.00	79.1	+1.5	94	11	87	65	16	71	22	73	71	81	2.53	−4.0	8	4,742	sw.	28	n.	25	16	7	8	4.5	0.0	0.0
Charleston	48	11	92	29.94	30.00	−.01	82.2	+1.2	97	1	89	68	14	75	23	77	75	86	8.28	+1.3	10	7,063	ne.	36	se.	2	10	14	7	4.8	0.0	0.0
Columbia, S. C	351	41	57	29.63	30.00	−.01	80.9	+1.3	98	21	91	61	16	71	28	73	70	78	4.58	−2.2	9	3,737	s.	27	n.	21	13	12	6	4.5	0.0	0.0
Due West	711	10	55	29.27	30.03	----	79.8	----	100	28	91	60	16	69	31	----	----	----	1.34	----	6	4,366	s.	37	se.	29	9	16	6	4.7	0.0	0.0
Greenville, S. C	1,039	113	122	28.92	29.99	----	78.8	+3.0	98	28	89	61	16	69	29	70	66	72	2.65	----	7	4,823	ne.	32	nw.	9	13	13	5	4.2	0.0	0.0
Augusta	180	62	77	29.79	29.98	−.03	82.4	+2.0	100	21	93	62	16	72	27	74	71	76	2.86	−2.7	11	3,244	s.	27	ne.	29	14	15	2	3.8	0.0	0.0
Savannah	65	150	194	29.92	29.99	−.02	82.3	+1.6	97	26	91	69	16	74	25	75	73	80	2.63	−4.9	10	6,986	sw.	48	n.	9	16	14	1	3.6	0.0	0.0
Jacksonville	43	209	245	29.94	29.99	−.02	82.2	+0.5	95	8	90	68	9	75	25	75	73	80	3.55	−2.7	12	7,519	sw.	43	ne.	4	12	16	3	4.4	0.0	0.0
Florida Peninsula							83.8	+1.5										73	3.57	−3.0										5.4		
Key West	22	10	64	29.94	29.96	−.02	84.9	+1.4	93	12	90	71	30	80	17	77	74	72	3.85	−0.8	13	5,921	se.	26	se.	29	9	15	7	5.1	0.0	0.0
Miami	25	71	79	29.96	29.99	----	82.9	+0.9	93	24	88	70	22	77	19	76	74	75	3.40	−3.0	16	5,332	e.	24	sw.	25	4	15	12	6.1	0.0	0.0
Sand Key	23	39	72	29.95	29.98	.00	83.4	----	90	9	86	74	30	81	11	77	73	70	1.32	----	14	8,118	e.	42	se.	29	11	12	8	5.0	0.0	0.0
Tampa	35	79	87	29.95	29.98	−.02	83.6	+2.1	95	22	91	70	22	76	25	75	72	75	3.47	−5.1	9	3,869	e.	30	ne.	22	8	16	7	5.6	0.0	0.0
East Gulf States							82.6	+2.8										73	2.47	−2.4										4.0		
Atlanta	1,174	190	216	28.80	30.01	.00	80.4	+3.4	97	29	90	65	17	70	27	70	67	70	3.87	−0.6	6	5,383	nw.	30	se.	29	15	12	4	4.4	0.0	0.0
Macon	370	78	87	29.60	29.99	−.02	81.8	+1.9	99	28	92	66	14	71	29	72	69	72	3.00	−1.2	8	3,395	ne.	30	n.	3	12	16	3	4.4	0.0	0.0
Thomasville	273	49	58	29.70	29.99	−.01	82.6	+1.6	98	25	93	69	31	72	27	73	70	76	2.88	−2.2	8	2,725	sw.	19	sw.	12	7	19	5	5.3	0.0	0.0
Apalachicola	36	42	49	29.95	29.99	----	82.2	----	97	22	89	71	16	76	23	75	73	79	4.66	----	10	4,190	w.	48	n.	22	19	10	2	3.4	0.0	0.0
Pensacola	56	149	185	29.93	29.99	+.01	82.8	+1.9	96	22	89	70	14	76	20	75	72	75	1.92	−5.2	7	7,383	n.	48	n	24	13	14	4	4.1	0.0	0.0
Anniston	741	9	57	29.25	30.03	+.04	80.4	+4.0	101	28	93	58	14	68	35	----	----	----	2.38	−2.1	6	2,738	s.	21	n.	2	21	8	2	2.6	0.0	0.0
Birmingham	700	11	48	29.26	30.01	+.02	82.6	+3.4	103	24	95	62	14	71	33	70	67	69	0.61	−3.9	6	3,592	s.	24	se.	29	12	15	4	4.1	0.0	0.0
Mobile	57	125	161	29.93	29.99	+.01	83.8	+3.3	100	24	93	69	14	75	23	75	72	75	3.21	−3.6	7	5,602	sw.	35	se.	5	15	15	1	3.9	0.0	0.0
Montgomery	223	100	112	29.75	30.00	+.01	82.8	+2.0	98	29	93	67	14	73	25	73	70	73	3.99	−0.2	11	3,739	s.	30	n.	3	15	12	4	4.0	0.0	0.0
Corinth	469	6	----	----	----	----	81.8	----	100	28	94	60	14	70	35	----	----	----	6.22	----	8	----	s.	----	----	----	13	16	2	----	0.0	0.0
Meridian	375	85	93	29.60	29.98	.00	82.6	+3.1	100	23	94	65	14	71	30	72	69	71	2.18	−1.4	8	3,138	sw.	30	nw.	9	16	11	4	3.9	0.0	0.0
Vicksburg	247	65	73	29.73	30.00	+.02	83.2	+2.4	97	26	93	66	13	73	29	73	70	73	0.86	−2.7	8	4,060	se.	33	se.	29	19	10	2	3.2	0.0	0.0
New Orleans	53	76	84	29.93	29.98	.00	85.8	+3.6	100	25	94	75	9	78	22	76	72	73	2.26	−3.4	7	3,551	sw.	25	nw.	9	11	16	4	4.4	0.0	0.0
West Gulf States							84.7	+2.9										69	1.28	−1.6										3.3		
Shreveport	249	77	93	29.70	29.96	−.01	86.0	+4.0	102	10	97	69	17	75	28	72	67	62	1.66	−0.6	5	4,435	s.	29	nw.	17	22	8	1	2.4	0.0	0.0
Bentonville	1,303	11	44	----	----	----	78.9	+2.4	94	28	89	63	14	68	27	----	----	----	3.04	----	8	2,920	s.	16	s.	23	19	11	1	[illegible]	0.0	0.0
Fort Smith	457	79	94	29.46	29.92	−.05	84.6	+4.1	101	5	96	60	13	72	29	72	67	64	1.72	−1.9	6	5,157	e.	37	nw.	10	[illegible]	11	7	4.6	0.0	0.0
Little Rock	357	136	144	29.59	29.96	−.02	82.8	+3.0	99	5	93	65	13	72	32	71	66	64	1.74	−1.9	7	5,079	s.	35	n.	24	18	7	6	3.5	0.0	0.0
Brownsville	57	53	61	29.85	29.91	----	85.0	+1.1	97	25	93	74	12	77	21	76	74	76	0.28	----	3	5,983	s.	23	sw.	6	27	3	1	1.7	0.0	0.0
Corpus Christie	20	11	73	29.93	29.95	+.02	84.0	+1.4	96	25	90	74	25	78	22	77	74	81	0.02	−2.3	1	9,637	se.	32	se.	6	26	1	4	2.0	0.0	0.0
Dallas	512	109	117	29.40	29.94	----	87.0	----	104	24	97	72	13	77	24	----	----	----	0.81	----	4	6,440	s.	26	nw.	6	19	12	0	3.5	0.0	0.0
Fort Worth	670	106	114	29.21	29.90	−.04	87.0	+4.0	104	24	97	69	6	77	31	72	66	56	3.77	+1.9	8	7,517	s.	40	nw.	6	14	15	2	4.0	0.0	0.0
Galveston	54	106	114	29.92	30.02	+.02	85.2	+2.2	100	24	90	76	31	80	18	78	75	76	0.49	−4.5	3	7,208	s.	22	n.	26	22	9	0	2.5	0.0	0.0
Groesbeck	461	11	56	29.47	29.94	----	86.0	----	103	24	97	70	14	76	29	----	----	----	1.72	----	3	7,153	s.	30	n.	31	14	15	2	3.5	0.0	0.0
Houston	138	111	121	29.83	29.97	----	85.6	+2.4	103	24	96	71	13	76	29	----	----	----	0.64	----	8	4,256	s.	29	ne.	13	11	18	2	3.5	0.0	0.0
Palestine	510	64	72	29.43	29.95	−.02	85.4	+3.6	102	24	96	69	14	75	27	73	68	65	0.55	−1.7	3	5,189	sw.	30	ne.	28	9	19	3	4.4	0.0	0.0
Port Arthur	34	58	66	29.90	29.92	----	85.0	----	99	12	92	73	13	78	24	76	73	76	0.72	----	2	5,609	s.	30	ne.	25	16	11	4	3.8	0.0	0.0
San Antonio	693	119	132	29.22	29.92	−.01	86.0	+2.5	102	25	97	73	28	75	24	73	68	63	T.	−2.7	0	5,584	se.	25	e.	26	20	9	2	2.9	0.0	0.0
Taylor	583	55	63	29.37	29.98	+.03	86.0	+4.3	105	25	97	69	13	75	30	----	----	----	1.55	−0.9	4	6,620	s.	28	ne.	13	17	12	2	3.2	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, August, 1924*—Continued

Districts and stations	Elevation of instruments			Pressure			Temperature of the air												Precipitation			Wind										
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Total	Departure from normal	Days with 0.01, or more	Total movement	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							**75.8**	**+0.8**										**70**	**2.21**	**−1.2**										**4.2**		
Chattanooga	762	189	213	29.19	29.98	−.02	80.4	+2.9	100	28	91	64	15	70	30	69	64	66	2.04	−1.7	6	4,208	se.	34	sw.	6	16	14	1	3.5	0.0	0.0
Knoxville	996	102	111	28.97	29.99	−.02	78.4	+2.2	98	29	89	61	15	68	30	69	66	73	1.77	−2.2	7	3,677	ne.	27	s.	6	8	18	5	5.4	0.0	0.0
Memphis	399	76	97	29.56	29.98	.00	81.6	+2.2	96	4	90	64	13	73	24	72	68	68	0.67	−2.5	7	4,659	sw.	40	nw.	10	20	7	4	3.1	0.0	0.0
Nashville	546	168	191	29.43	30.01	+.01	79.6	+1.8	96	22	90	59	15	69	31	70	66	68	2.59	−0.9	7	5,052	w.	38	nw.	11	20	7	4	3.1	0.0	0.0
Lexington	989	193	230	28.96	30.00	−.01	75.1	+0.6	94	31	85	54	14	65	32				2.28	−1.3	8	7,953	sw.	39	w.	6	16	11	4	3.8	0.0	0.0
Louisville	525	188	234	29.43	30.01	+.01	76.8	−0.2	95	31	87	56	14	67	30	67	63	69	2.50	−1.0	10	6,094	n.	44	sw.	20	19	8	4	3.4	0.0	0.0
Evansville	431	139	175	29.54	30.00	+.01	78.2	+0.8	98	30	88	57	14	68	31	69	64	68	0.92	−2.3	7	6,389	sw.	35	n.	9	13	17	1	3.7	0.0	0.0
Indianapolis	822	194	230	29.13	30.00	.00	73.4	−0.3	96	4	83	51	14	64	25	66	62	71	4.77	+1.4	10	7,231	sw.	56	n.	9	14	10	7	4.4	0.0	0.0
Royal Center	736	11	55	29.20	29.99		69.8		94	4	81	48	14	59	32				3.49		11	5,507	s.	39	w.	8	8	13	10	5.5	0.0	0.0
Terre Haute	575	96	129	29.37	29.98		74.6		97	5	85	51	14	64	27	66	63	71	5.55		10	6,079	s.	37	n.	8	13	13	5	4.4	0.0	0.0
Cincinnati	628	11	51	29.34	30.00	−.01	74.3	+0.7	96	5	86	52	15	63	32		63	69	3.03	−0.3	9	4,059	sw.	28	nw.	19	18	7	6	3.7	0.0	0.0
Columbus	824	179	222	29.15	30.01	.00	73.6	+0.3	95	31	84	52	18	63	31	64	60	66	0.33	−2.9	7	6,059	n.	35	nw.	22	11	17	3	4.4	0.0	0.0
Dayton	899	137	173	29.05	29.98		73.5	+0.1	94	31	84	52	15	63	33	65	60	68	1.27	−1.7	7	5,350	sw.	38	nw.	31	18	8	5	3.9	0.0	0.0
Elkins	1,947	59	67	28.02	30.02	.00	69.1	0.0	90	6	80	46	19	58	37	63	62	87	3.81	+0.2	9	2,601	nw.	21	ne.	9	9	17	5	5.1	0.0	0.0
Parkersburg	638	77	84	29.37	30.02	+.02	74.9	+1.0	98	6	86	50	15	64	34	65	62	71	1.44	−2.1	8	3,079	s.	26	nw.	13	13	10	8	4.6	0.0	0.0
Pittsburgh	842	353	410	29.11	30.00	−.01	72.2	−0.7	93	31	82	50	19	63	30	65	61	72	3.46	+0.3	12	6,346	sw.	48	nw.	5	10	10	11	5.4	0.0	0.0
Lower Lake Region							**69.4**	**−0.3**										**71**	**2.16**	**−0.8**										**4.8**		
Buffalo	767	247	280	29.17	29.99	.00	67.8	−0.8	85	30	75	50	18	61	29	62	59	76	2.69	−0.3	8	9,507	sw.	52	nw.	4	7	16	8	5.5	0.0	0.0
Canton	448	10	61	29.46	29.93		65.8	−2.0	86	31	76	42	15	56	33				3.10	+0.4	13	5,581	sw.	47	w.	6	17	9	5	3.7	0.0	0.0
Oswego	335	76	91	29.60	29.96	−.03	67.4	−1.0	92	31	75	51	3	60	26	62	59	75	2.05	−0.6	8	5,704	sw.	23	ne.	20	13	8	10	4.9	0.0	0.0
Rochester	523	86	102	29.42	29.98	−.01	68.8	−0.4	92	30	78	48	2	60	30	62	58	71	2.71	−0.2	11	4,342	sw.	32	w.	27	12	10	9	5.0	0.0	0.0
Syracuse	597	97	113	29.36	30.00	+.01	68.8	+0.2	92	31	78	49	3	60	29				1.59	−1.7	10	6,036	s.	31	s.	22	9	15	7	5.5	0.0	0.0
Erie	714	130	166	29.23	29.98	+.03	70.0	+0.4	92	6	78	51	19	62	27	63	58	69	2.61	−0.6	10	8.257	nw.	44	sw.	6	10	18	3	4.4	0.0	0.0
Cleveland	762	190	201	29.18	29.99	.00	70.0	0.0	94	6	77	51	19	63	26	63	58	68	0.90	−2.2	11	7,412	s.	31	n.	17	11	12	8	5.0	0.0	0.0
Sandusky	629	62	70	29.32	30.00	−.01	71.6	−0.2	95	6	80	54	15	64	28				2.62	−0.8	12	4,846	sw.	28	n.	13	6	15	10	5.6	0.0	0.0
Toledo	628	208	243	29.32	30.00	.00	71.4	+0.1	95	6	81	51	18	62	26	63	58	69	1.66	−1.0	10	8,311	sw	72	w.	8	14	14	3	3.9	0.0	0.0
Fort Wayne	856	113	124	29.09	30.00		71.4	+0.3	94	4	82	50	17	61	30	63	59	70	2.22		9	5,204	sw.	33	w.	8	12	14	5	5.0	0.0	0.0
Detroit	730	218	258	29.22	30.00	−.01	70.6	+0.3	94	31	80	52	18	62	25	62	58	68	1.71	−1.1	8	6,213	sw.	28	sw.	31	12	16	3	4.2	0 0	0.0
Upper Lake Region							**65.2**	**−1.4**										**78**	**4.30**	**+1.3**										**5.2**		
Alpena	609	13	92	29.31	29.97	−.03	63.0	−1.1	88	30	72	44	18	54	28	59	56	79	1.94	−1.4	11	7,257	nw.	33	se.	3	7	15	9	5.8	0.0	0.0
Escanaba	612	54	60	29.29	29.95	−.04	62.1	−2.2	80	22	70	42	1	54	22	58	55	80	5.69	+2.1	13	6,562	s.	33	s.	2	14	9	8	4.6	0.0	0.0
Grand Haven	632	54	89	29.30	29.96	−.03	65.4	−1.7	87	5	73	46	18	58	26	61	59	80	4.18	+1.6	9	6,420	s.	36	se.	19	8	17	6	5.0	0.0	0.0
Grand Rapids	707	70	87	29.23	29.98	−.01	68.0	−2.0	92	30	78	46	18	58	29	62	58	71	2.51	−0.1	8	3,387	w.	24	w.	5	9	12	10	5.7	0.0	0.0
Houghton	668	62	99	29.20	29.92	−.05	62.8	−0.9	92	29	71	45	18	54	31				4.24	+1.4	13	6,819	w.	37	nw.	7	11	10	10	5.2	0.0	0.0
Lansing	878	11	62	29.05	29.98		66.8	−1.7	90	5	79	42	18	55	33	61	58	70	2.01	−0.6	9	2,997	sw.	18	se.	19	10	14	7	4.9	0.0	0.0
Ludington	637	60	66	29.28	29.97		64.2		84	5	71	48	18	58	24	61	59	84	6.97		13	6,592	s.	32	se.	3	14	12	5	4.1	0.0	0.0
Marquette	734	77	111	29.16	29.96	−.02	63.4	−0.4	89	29	72	44	1	55	26	58	55	78	4.46	+1.6	15	7,226	w.	44	se.	3	9	13	9	5.7	0.0	0.0
Port Huron	638	70	120	29.29	29.98	−.01	67.0	−0.8	92	31	76	46	18	58	27	61	58	76	1.74	−0.9	8	6,537	ne.	32	w.	5	10	17	4	4.6	0.0	0.0
Saginaw	641	69	77	29.30	29.98		66.4	−2.3	89	30	77	44	18	56	28	61	57	74	3.18	+0.3	8	4,844	nw.	29	sw.	4	6	15	10	6.0	0.0	0.0
Sault Sainte Marie	614	11	52	29.26	29.95	−.04	61.0	−1.1	84	30	70	44	14	52	31	56	54	82	4.92	+1.8	11	4,727	nw.	28	nw.	16	7	14	10	6.0	0.0	0.0
Chicago	823	140	310	29.12	29.99	−.01	71.0	−1.8	92	5	78	58	10	64	27	64	60	72	8.12	+5.2	12	7,335	s.	54	s.	8	9	11	11	5.3	0.0	0.0
Green Bay	617	109	144	29.27	29.93	−.06	66.0	−1.7	90	26	75	47	17	57	27	60	57	76	4.82	+1.7	11	7,064	s.	44	s.	3	12	9	10	5.1	0.0	0.0
Milwaukee	681	125	139	29.24	29.97	−.03	67.6	−1.6	91	26	75	52	17	60	27	62	59	77	8.06	+5.2	11	6,305	sw.	52	se.	19	12	11	8	4.8	0.0	0.0
Duluth	1,133	11	47	28.71	29.92	−.05	61.9	−0.7	89	26	72	42	18	52	30	56	54	82	4.40	+0.9	13	8,049	ne.	33	sw.	7	9	11	11	5.3	0.0	0.0
North Dakota							**64.9**	**−1.3**										**66**	**2.13**	**−0.2**										**4 3**		
Moorhead	940	50	58	28.89	29.89	−.07	66.4	+0.3	93	28	77	43	13	55	33	58	53	67	2.99	−0.1	9	5,736	nw.	28	e.	19	19	11	1	3.4	0.0	0.0
Bismarck	1,674	8	57	28.17	29.93	−.01	65.9	−1.5	96	28	78	44	31	53	40	56	50	64	1.91	−0.1	5	6,119	nw.	37	nw.	30	13	6	12	5.3	0.0	0.0
Devils Lake	1,478	11	44	28.34	29.89	−.05	63.4	−1.7	93	29	76	39	16	51	40	55	51	71	2.39	−0.4	11	6,343	w.	35	nw.	30	14	12	5	4.3	0.0	0.0
Ellendale	1,457	10	56	28.36	29.90		65.9		96	28	79	39	13	53	40				2.74		8	9,163	nw.	47	se.	2	13	11	7	4.3	0.0	0.0
Grand Forks	835	12	89				63.2		90	25	76	38	13	51	44				2.43		11		nw.	27	ne.	5	16	10	5		0.0	0.0
Williston	1,878	41	48	27.94	29.88	−.05	63.8	−2.3	96	28	76	41	10	51	42	54	48	64	1.22	−0.1	8	5,766	w.	64	nw.	1	14	10	7	4.2	0.0	0.0
Upper Mississippi Valley							**72.4**	**−0.5**										**76**	**5.88**	**+2.6**										**4.4**		
Minneapolis	918	102	208	28.93	29.90		68.1	−1.8	92	26	78	48	13	58	27				7.35	+3.7	16	7,371	n.	57	s.	2	10	12	9	5.1	0.0	0.0
St. Paul	837	236	261	29.03	29.92	−.05	67.0	−2.4	91	26	77	49	13	57	28				6.51	+3.0	14	7,779	se.	56	se.	2	12	16	3	4.1	0.0	0.0
La Crosse	714	11	48	29.18	29.94	−.04	68.2	−1.8	92	26	78	48	14	58	26				9.25	+5.8	11	3,003	nw.	20	sw.	21	10	14	7	5.1	0.0	0.0
Madison	974	70	78	28.94	29.97	−.02	68.2	−1.6	89	21	76	50	14	60	27	62	59	76	7.23	+4.0	14	5,595	s.	36	e.	8	10	13	8	5.1	0.0	0.0
Wausau	1,247	4		28.65	29.97		64.4		88	26	74	41	18	54	33				5.85		12		se.				15	3	13	5.2	0.0	0.0
Charles City	1,015	10	49	28.88	29.94	−.03	68.7	−2.0	93	3	79	48	13	59	29	63	60	78	7.59	+4.2	11	4,226	se.	26	sw.	15	11	14	6	4.2	0.0	0.0
Davenport	606	71	79	29.31	29.96	−.02	72.8	−0.3	93	3	82	53	14	64	28	66	63	76	8.03	+4.4	12	4,478	s.	34	nw.	8	15	7	9	4.4	0.0	0.0
Des Moines	861	84	97	29.03	29.92	−.05	73.6	+0.5	97	3	83	55	10	65	24	67	64	76	4.15	+0.5	11	5,027	sw.	32	sw.	30	10	10	11	5.1	0.0	0.0
Dubuque	700	81	96	29.20	29.93	−.05	70.0	−1.7	92	3	79	51	14	61	27	64	61	75	7.05	+4.0	13	4,051	s.	31	nw.	4	11	10	10	5.3	0.0	0.0
Keokuk	614	64	78	29.29	29.95	−.03	75.4	+0.4	97	5	85	54	14	66	28	68	66	75	5.60	+2.4	8	4,377	s.	34	sw.	5	11	11	9	4.8	0.0	0.0
Cairo	358	87	93	29.60	29.97	−.02	78.2	+0.4	95	4	87	62	14	70	28	71	69	78	2.84	−0.1	7	4,420	s.	42	n.	9	17	6	8	3.9	0.0	0.0
Peoria	609	11	45	29.33	29.99	.00	72.7	+0.2	95	5	83	51	14	62	29	67	65	80	7.15	+4.2	10	3,599	s.	21	n.	19	19	10	2	3.2	0.0	0.0
Springfield, Ill	636	10	91	29.29	29.95	−.04	75.4	+0.9	98	5	86	51	14	65	29	68	65	77	3.10	+0.3	11	5,166	s.	39	nw.	8	19	7	5	3.3	0.0	0.0
Hannibal	534	74	109	29.38	29.94	−.04	76.8	+1.8	97	5	86	53	12	67	29				2.54	−0.8	9	5,629	sw.	38	nw.	8	14	15	2	3.7	0.0	0.0
St. Louis	568	265	303	29.36	29.96	−.03	78.2	+0.9	95	27	87	57	14	69	27	69	65	70	3.90	+1.2	9	8,194	s.	56	nw.	8	17	9	5	3.5	0.0	0.0
Missouri Valley							**75.0**	**+1.1**										**71**	**3.80**	**+0.4**										**3.9**		
Columbia, Mo	784	11	84	29.12	29.93	−.04	77.1	+1.5	95	20	87	53	12	67	29				3.09	0.0	9	4,697	s.	39	nw.	24	16	12	3	3.7	0.0	0.0
Kansas City	963	161	181	28.91	29.91	−.06	78.2	+1.6	95	3	87	59	10	69	26	70	67	72	3.12	−1.6	8	6,855	s.	50	n.	24	18	10	3	3.5	0.0	0.0
St. Joseph	967	11	49	28.90	29.90		77.8		97	26	88	57	12	68	27	69	65	73	3.17		10	5,554	se.	34	nw.	5	16	12	3	3.3	0.0	0.0
Springfield, Mo	1,324	98	104	28.59	29.97	.00	77.0	+1.3	91	23	86	60	12	68	23	70	68	77	5.97	+1.7	9	6,416	s.	34	s.	15	24	5	2	2.2	0.0	0.0
Iola	984	11	50	28.90	29.91	−.05	78.4	+2.1	93	20	89	55	12	68	27				6.40	+2.9	9	4,282	s.	25	n.	5	14	14	3	3.9	0.0	0.0
Topeka	987	92	107				78.0	+1.8	97	27	88	57	12	68	30				6.93	+2.6	14	7,204	s.	42	w.	24	17	12	2	3.3	0.0	0.0
Drexel	1,299	10	54	28.53	29.88		73.2		95	3	84	53	31	63	30				2.11		5	6,381	se.	39	sw.	5	13	11	7	4.3	0.0	0.0
Lincoln	1,189	11	84	28.65	29.88	−.07	77.0	+2.6	101	3	88	56	10	66	31	67	63	68	1.10	−2.6	8	7,028	se.	38	w.	5	12	10	9	4.7	0.0	0.0
Omaha	1,105	115	122	28.75	29.90	−.06	76.0	+1.6	99	3	86	59	16	66	28	67	64	72	1.67	−2.0	10	5,085	se.	44	nw.	8	12	13	6	4.2	0.0	0.0
Valentine	2,598	47	54	27.24	29.90	−.04	71.4	−0.3	100	2	84	42	31	58	38	61	56	66	3.38	+0.6	9	6,531	s.	48	sw.	20	10	16	5	4.3	0.0	0.0
Sioux City	1,135	94	164	28.72	29.90	−.05	72.7	+0.7	96	26	82	53	11	63	36	66	62	73	4.24	+1.2	11	7,705	se.	50	nw.	8	13	9	9	4.4	0.0	0.0
Huron	1,306	59	74	28.54	29.92	−.03	69.8	+0.4	95	25	81	48	31	58	35	61	57	71	4.50	+1.9	14	6,355	se.	48	sw.	20	16	11	4	3.7	0.0	0.0
Pierre	1,572	70	75	28.24	29.87	−.07	72.4	−0.4	103	28	84	47	31	60	36	62	56	63	2.74	+0.7	8	6,067	e.	60	w.	21	14	12	5	4.0	0.0	0.0
Yankton	1,233	49	57	28.60	29.89	−.06	72.2	+0.2	95	26	83	52	11	61	36				2.52	−0.6	9	4,919	e.	30	s.	29	8	19	4	4.8	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, August, 1924*—Continued

Districts and stations	Elevation of instruments			Pressure			Temperature of the air									Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation			Wind					Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range				Total	Departure from normal	Days with 0.01, or more	Total movement	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date						
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Northern Slope							**66.1**	**−0.2**										**52**	**0.77**	**−0.5**										**3.6**		
Billings	3,140	5	----	----	----	----	65.8	----	102	28	85	36	30	47	55	----	----	----	0.12	----	3	----	nw.	----	----	----	14	14	3	----	0.0	0.0
Havre	2,505	11	44	27.32	29.91	.00	64.8	−0.6	93	28	80	41	11	50	46	53	46	62	1.39	+0.1	8	4,548	sw.	46	sw.	1	17	12	2	3.7	0.0	0.0
Helena	4,110	87	112	25.80	29.91	−.03	65.4	+0.4	96	28	79	44	5	52	38	49	36	42	0.25	−0.4	5	6,203	sw.	49	sw.	28	15	12	4	3.9	0.0	0.0
Kalispell	2,973	48	56	26.90	29.91	−.02	61.2	−1.6	89	26	75	36	30	47	40	49	39	53	0.74	−0.2	5	4,201	nw.	34	w.	29	13	14	4	4.2	0.0	0.0
Miles City	2,371	48	55	27.43	29.94	+.01	68.2	−3.3	103	28	82	42	31	54	43	55	47	54	0.66	−0.4	4	3,731	ne.	29	w.	18	20	7	4	3.0	0.0	0.0
Rapid City	3,259	50	58	26.58	29.92	−.01	69.6	+0.1	98	28	83	44	31	56	44	56	46	51	1.19	−0.9	8	5,200	n.	46	nw.	18	18	9	4	3.0	0.0	0.0
Cheyenne	6,088	84	101	24.06	29.87	−.05	66.4	+0.8	91	2	81	44	22	52	39	52	42	47	0.23	−1.2	4	7,618	w.	37	w.	4	10	16	5	4.5	0.0	0.0
Lander	5,372	60	68	24.66	29.87	−.05	66.4	+0.9	92	28	83	40	22	50	43	50	36	39	0.16	−0.4	1	4,179	sw.	36	nw.	19	19	9	3	2.6	0.0	0.0
Sheridan	3,790	10	47	26.09	29.93	----	64.5	----	100	28	82	38	31	47	55	52	43	55	0.35	----	4	3,058	nw.	29	nw.	29	19	11	1	2.9	0.0	0.0
Yellowstone Park	6,200	11	48	23.94	29.93	.00	58.6	−2.3	87	28	75	35	30	42	45	45	33	47	1.36	+0.3	5	5,089	s.	37	nw.	31	13	15	3	3.5	0.0	0.0
North Platte	2,821	11	51	27.05	29.91	−.03	74.6	+3.8	100	18	88	53	22	61	41	63	58	67	0.96	−1.5	8	4,571	se.	25	s.	20	21	6	4	3.2	0.0	0.0
Middle Slope							**78.4**	**+2.4**										**56**	**1.76**	**−0.7**										**3.4**		
Denver	5,292	106	113	24.76	29.88	−.04	73.2	+2.5	98	2	87	54	9	60	35	54	41	38	0.02	−1.3	2	5,392	s.	38	n.	12	14	17	0	4.0	0.0	0.0
Pueblo	4,685	80	86	25.30	29.86	−.05	74.6	+1.9	100	2	90	50	27	59	45	56	44	43	0.15	−1.4	5	4,688	e.	31	w.	14	16	15	0	3.5	0.0	0.0
Concordia	1,392	50	58	28.43	29.86	−.09	79.5	+3.0	102	3	91	57	10	68	30	68	62	63	2.38	−0.4	9	6,249	s.	39	s.	7	15	14	2	4.1	0.0	0.0
Dodge City	2,509	11	51	27.37	29.90	−.03	79.0	+1.3	105	3	91	61	31	67	33	66	61	64	3.23	+0.6	8	7,541	se.	46	ne.	12	20	7	4	3.2	0.0	0.0
Wichita	1,358	139	158	28.49	29.88	−.07	80.8	+2.5	102	19	91	61	12	71	27	70	65	66	1.70	−1.4	10	10,099	s.	44	sw.	5	12	16	3	4.5	0.0	0.0
Broken Arrow	765	11	52	29.12	29.93	----	81.4	----	98	24	92	61	12	71	28	----	----	----	1.48	----	8	8,129	s.	51	nw.	9	13	8	10	4.6	0.0	0.0
Muskogee	652	4	----	----	----	----	84.6	----	103	24	98	66	14	72	36	----	----	----	0.83	----	8	----	se.	----	----	----	12	10	9	----	0.0	0.0
Oklahoma City	1,214	10	47	28.66	29.90	−.04	83.0	+3.3	103	24	94	65	12	72	29	70	66	65	3.10	−0.1	9	7,234	s.	32	se.	9	10	13	8	4.8	0.0	0.0
Southern Slope							**82.6**	**+3.0**										**55**	**1.30**	**−1.0**										**2.9**		
Abilene	1,738	10	52	28.13	29.88	−.04	85.2	+3.2	103	15	96	68	17	74	31	69	62	54	1.51	−0.5	7	7,728	s.	31	s.	15	18	9	4	3.4	0.0	0.0
Amarillo	3,676	10	49	26.27	29.90	−.02	78.2	+2.5	101	8	91	61	16	66	32	66	60	63	3.57	+0.8	12	7,668	s.	35	ne.	9	21	9	1	3.6	0.0	0.0
Del Rio	944	64	71	28.93	29.88	−.02	88.0	+3.8	102	25	98	75	11	78	26	----	----	----	0.06	−2.6	0	8,614	se.	32	e.	26	28	3	0	1.4	0.0	0.0
Roswell	3,566	75	85	26.33	29.84	−.04	79.2	+2.6	101	9	93	55	30	66	37	62	52	47	0.12	−1.8	3	5,026	s.	34	ne.	25	18	11	2	3.2	0.0	0.0
Southern Plateau							**78.7**	**+1.3**										**38**	**0.69**	**−0.4**										**1.6**		
El Paso	3,762	110	133	26.15	29.80	−.04	82.7	+3.5	100	14	95	60	26	71	31	63	51	40	2.58	+0.9	5	6,595	nw.	58	n.	26	20	11	0	2.6	0.0	0.0
Santa Fe	7,013	38	53	23.35	29.85	−.04	68.0	+0.6	87	24	82	45	27	54	33	52	41	46	0.71	−1.6	10	4,239	e.	29	n.	25	21	9	1	3.1	0.0	0.0
Flagstaff	6,907	10	59	----	----	----	64.2	+1.4	85	27	81	40	22	48	40	----	----	47	0.37	----	3	6,100	w.	38	w.	29	23	8	0	----	0.0	0.0
Phoenix	1,108	11	81	28.65	29.76	−.03	89.4	+0.9	109	13	103	65	21	76	37	69	58	38	0.14	−0.8	1	3,862	w.	24	e.	11	25	6	0	1.5	0.0	0.0
Yuma	141	9	54	29.61	29.75	−.01	90.4	0.0	111	26	106	63	21	75	39	70	60	43	T.	−0.4	0	3,928	sw.	25	se.	29	31	0	0	0.2	0.0	0.0
Independence	3,957	5	25	25.93	29.87	+.06	77.4	+1.3	103	27	94	49	18	61	42	52	26	17	T.	−0.1	0	5,721	se.	39	w.	9	31	0	0	0.6	0.0	0.0
Middle Plateau							**71.3**	**+0.2**										**28**	**0.35**	**−0.5**										**2.0**		
Reno	4,532	74	81	25.47	29.88	+.04	68.7	+1.7	100	27	86	42	21	51	42	48	29	30	T.	−0.3	0	5,307	w.	37	w.	1	26	5	0	1.5	0.0	0.0
Tonopah	6,090	12	20	----	----	----	71.4	----	93	27	83	48	20	60	29	49	28	22	1.72	----	3	----	se.	----	----	----	----	----	----	----	0.0	0.0
Winnemucca	4,344	18	56	25.60	29.92	+.04	68.1	−1.2	102	27	88	36	21	48	53	47	27	27	0.01	−0.2	1	4,361	sw.	26	nw.	18	28	2	1	1.4	0.0	0.0
Modena	5,479	10	43	24.63	29.85	−.01	68.8	−0.4	96	27	87	40	21	50	47	48	26	27	0.31	−1.5	3	9,195	sw.	45	s.	17	27	3	1	1.3	0.0	0.0
Salt Lake City	4,360	163	203	25.58	29.85	−.06	75.4	+0.9	96	28	87	49	21	63	34	54	36	28	0.30	−0.5	3	5,266	s.	42	w.	13	21	8	2	2.7	0.0	0.0
Grand Junction	4,602	60	68	25.37	29.88	−.02	75.4	0.0	96	2	90	47	21	61	39	55	39	34	1.12	+0.1	4	4,791	se.	28	sw.	3	22	8	1	3.1	0.0	0.0
Northern Plateau							**69.7**	**−0.2**										**37**	**0.59**	**+0.2**										**3.0**		
Baker	3,471	48	53	26.43	29.96	+.01	64.3	−0.3	96	26	81	38	30	48	45	49	35	41	0.39	0.0	3	4,314	nw.	21	n.	29	13	9	9	4.1	0.0	0.0
Boise	2,739	78	86	27.10	29.90	−.03	70.4	−1.4	104	27	87	43	30	54	42	52	33	31	0.12	0.0	1	3,125	nw.	22	w.	18	27	3	1	1.4	0.0	0.0
Lewiston	757	40	48	29.12	29.91	−.04	72.8	0.0	104	12	88	44	30	58	43	----	----	----	0.62	+0.2	3	2,490	e.	24	nw.	29	21	3	7	2.9	0.0	0.0
Pocatello	4,477	60	68	25.45	29.85	−.07	70.1	+0.5	98	28	85	49	9	55	41	50	30	27	0.03	−0.5	1	5,750	se.	30	sw.	11	19	11	1	2.9	0.0	0.0
Spokane	1,929	101	110	27.92	29.92	−.03	67.8	−0.3	97	12	81	39	31	55	40	53	42	47	0.93	+0.4	6	4,246	sw.	23	nw.	3	14	9	8	4.3	0.0	0.0
Walla Walla	991	57	65	28.87	29.92	−.04	72.8	+0.1	100	11	86	47	30	60	35	56	42	38	1.25	+0.8	4	3,724	s.	18	n.	9	23	5	3	2.2	0.0	0.0
North Pacific Coast Region							**62.0**	**−0.2**										**77**	**0.97**	**+0.2**										**6.1**		
North Head	211	11	56	29.85	30.07	+.04	57.4	−0.2	66	25	60	49	31	54	10	56	54	92	1.48	+0.9	14	10,288	n.	54	s.	17	2	6	23	8.6	0.0	0.0
Port Angeles	29	8	53	----	30.06	----	57.0	----	72	26	65	42	29	50	28	----	----	----	0.06	−0.6	2	4,748	sw.	25	w.	28	13	12	6	----	0.0	0.0
Seattle	125	215	250	29.93	30.06	+.06	62.4	−0.7	80	11	70	49	30	54	26	56	52	71	0.70	+0.2	3	5,042	s.	25	n.	28	7	12	12	5.6	0.0	0.0
Tacoma	194	172	201	29.84	30.04	+.02	62.8	+0.2	81	12	71	46	30	54	28	----	----	----	1.07	+0.3	4	5,117	sw.	24	sw.	16	5	16	10	6.0	0.0	0.0
Tatoosh Island	86	9	57	29.95	30.05	+.05	54.8	−0.5	63	20	58	46	31	52	12	54	53	97	2.09	0.0	11	7,892	s.	39	s.	24	2	8	21	8.1	0.0	0.0
Yakima	1,071	5	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Medford	1,425	4	----	----	----	----	71.3	----	104	26	91	44	30	52	49	55	43	57	0.97	----	3	----	nw.	----	----	----	21	2	8	----	0.0	0.0
Portland, Oreg	153	68	106	29.86	30.02	+.01	66.5	−0.2	88	26	76	47	29	57	31	58	53	66	0.62	0.0	3	3,773	nw.	17	n.	3	12	9	10	5.4	0.0	0.0
Roseburg	510	9	57	29.48	30.02	+.02	68.0	0.0	95	26	82	44	31	54	40	57	48	58	0.76	+0.4	3	2,654	n.	15	n.	29	17	13	1	2.7	0.0	0.0
Middle Pacific Coast Region							**64.2**	**−0.7**										**66**	**0.23**	**+0.2**										**4.4**		
Eureka	62	73	89	29.97	30.04	+.04	56.4	+0.4	66	17	60	48	31	53	13	54	53	90	1.03	+0.9	6	3,582	nw.	19	sw.	17	4	6	21	7.5	0.0	0.0
Point Reyes	490	7	18	29.42	29.94	----	53.0	−1.5	65	17	56	47	15	50	15	----	----	----	0.00	----	0	14,509	nw.	50	nw.	15	2	5	24	8.7	0.0	0.0
Red Bluff	332	50	56	29.51	29.85	−.01	78.3	−1.4	108	26	94	55	17	62	39	60	46	38	0.11	+0.1	2	3,497	se.	16	se.	15	28	2	1	1.8	0.0	0.0
Sacramento	69	106	117	29.81	29.88	+.03	72.2	−0.7	102	26	88	56	10	56	43	59	49	53	T.	0.0	0	6,783	s.	30	s.	8	30	1	0	0.7	0.0	0.0
San Francisco	155	208	243	29.79	29.96	+.04	59.1	0.0	71	24	65	52	23	53	19	54	52	85	0.01	0.0	1	7,669	sw.	36	w.	15	9	12	10	5.5	0.0	0.0
San Jose	141	12	110	29.80	29.95	----	65.9	−0.8	90	26	79	47	8	53	35	----	----	----	T.	0.0	0	4,555	nw.	20	nw.	1	24	7	0	2.4	0.0	0.0
South Pacific Coast Region							**69.7**	**−1.7**										**66**	**0.01**	**0.0**										**2.3**		
Fresno	327	89	98	29.52	29.86	+.04	79.8	−0.9	109	27	96	55	18	63	39	59	43	34	T.	0.0	0	6,143	nw.	25	nw.	16	30	1	0	0.4	0.0	0.0
Los Angeles	338	159	191	29.56	29.92	+.04	69.1	−2.0	86	10	79	56	26	60	24	61	57	74	0.00	0.0	0	3,490	sw.	14	sw.	9	23	7	1	2.5	0.0	0.0
San Diego	87	62	70	29.82	29.91	+.02	67.0	−1.7	76	12	72	60	26	62	13	62	60	82	T.	0.0	0	4,627	nw.	19	nw.	17	15	14	2	4.1	0.0	0.0
San Luis Obispo	201	32	40	29.75	29.97	+.03	63.0	−2.1	83	28	75	46	2	51	34	54	50	76	0.04	0.0	3	2,859	nw.	18	nw.	18	27	4	0	2.2	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.88	29.96	----	80.3	−0.2	90	24	85	73	24	76	17				4.04	−3.4	18	9,785	e.	43	ne.	29	9	11	11	5.8	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	29.74	29.86	+.02	78.8	−1.3	90	30	84	71	14	73	18	75	74	91	14.46	+6.6	26	3,366	nw.	29	n.	11	0	9	22	8.1	0.0	0.0
Colon	36	7	97	29.83	29.87	+.01	80.6	+0.5	90	14	86	74	10	75	16	76	75	88	7.42	−7.5	25	4,591	s.	26	ne.	8	0	8	23	8.3	0.0	0.0
Alaska																																
Juneau	80	11	54	29.86	29.95	----	55.3	----	78	7	62	42	28	49	26	52	50	86	7.99	----	21	4,380	s.	27	nw.	2	4	5	22	8.0	0.0	0.0

TABLE 2.—*Data furnished by the Canadian Meteorological Service, August, 1924*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*In.*	*In.*	*In.*
St. Johns, N. F.	125												
Sydney, C. B. I.	48	29.89	29.94	−.01	65.5	+2.2	73.5	57.5	84	44	6.64	+3.02	0.0
Halifax, N. S.	88	29.84	29.94	−.02	66.0	+2.4	75.2	56.7	84	45	9.16	+4.81	0.0
Yarmouth, N. S.	65	29.83	29.90	−.07	60.8	+0.6	68.8	52.9	78	45	6.25	+2.24	0.0
Charlottetown, P. E. I.	38	29.86	29.90	−.04	65.5	+1.2	72.1	59.0	84	51	3.13	−0.61	0.0
Chatham, N. B.	28	29.82	29.85	−.08	64.2	+1.0	75.4	53.1	87	42	3.22	−0.82	0.0
Father Point, Que.	20	29.86	29.88	−.03	53.0	−2.6	61.9	44.2	70	38	3.40	+0.35	0.0
Quebec, Que.	296	29.62	29.94	+.01	64.5	+1.4	72.5	56.5	81	48	3.62	−0.21	0.0
Montreal, Que.	187	29.72	29.92	−.03	67.4	+1.0	75.8	59.1	86	50	3.06	−0.51	0.0
Stonecliffe, Ont.	489												
Ottawa, Ont.	236	29.66	29.92	−.04	67.5	+2.7	79.0	56.1	90	44	3.34	+0.31	0.0
Kingston, Ont.	285	29.65	29.95	−.03	66.5	−0.5	73.7	59.2	81	50	4.11	+1.73	0.0
Toronto, Ont.	379	29.56	29.95	−.04	66.9	+0.9	77.1	56.7	90	48	3.92	+1.16	0.0
Cochrane, Ont.	930				59.2		70.1	48.4	81	35	2.98		0.0
White River, Ont.	1,244	28.58	29.88	−.08	56.5	+0.1	68.9	44.1	80	31	3.72	+0.42	0.0
Port Stanley, Ont.	592												
Southampton, Ont.	656	29.26			62.5	−1.3	71.0	54.1	83	45	3.49	+1.24	0.0
Parry Sound, Ont.	688	29.27	29.95	−.03	64.0	+0.5	74.6	53.5	87	45	1.42	−1.30	0.0
Port Arthur, Ont.	644	29.21	29.92	−.04	60.3	+0.8	69.1	51.5	80	42	5.43	+2.68	0.0
Winnipeg, Man.	760	29.05	29.87	−.07	62.9	−0.5	74.4	51.4	89	38	1.37	−1.30	0.0
Minnedosa, Man.	1,690	28.09	29.88	−.06	58.3	−1.1	69.7	47.0	83	35	3.27	+1.17	0.0
Le Pas, Man.	860				55.9		67.9	43.9	85	22	2.60		0.0
Qu'Appelle, Sask.	2,115	27.64	29.85	−.08	58.7	−2.8	70.2	47.2	82	39	2.80	+1.16	0.0
Medicine Hat, Alb.	2,144	27.59	29.81	−.11	65.3	−0.4	78.3	52.3	90	42	2.05	+0.38	0.0
Moose Jaw, Sask.	1,759				62.0		74.0	50.0	90	40	2.46		0.0
Swift Current, Sask.	2,392	27.38	29.86	−.07	61.8	−2.2	75.1	48.5	88	39	2.48	+0.57	0.0
Calgary, Alb.	3,428												
Banff, Alb.	4,521	25.40	29.90	−.01	55.0	−1.3	67.7	42.4	81	29	2.71	+0.18	0.0
Edmonton, Alb.	2,150	27.60	29.85	−.07	58.0	−0.8	69.1	46.9	80	35	2.88	+0.75	0.0
Prince Albert, Sask.	1,450	28.35	29.91	−.01	57.9	−1.0	68.8	47.1	81	40	3.94	+1.79	0.0
Battleford, Sask.	1,592	28.16	29.88	−.03	60.5	−2.1	73.2	47.8	86	38	2.72	+0.36	0.0

(Plotted by Wilfred P. Day.)

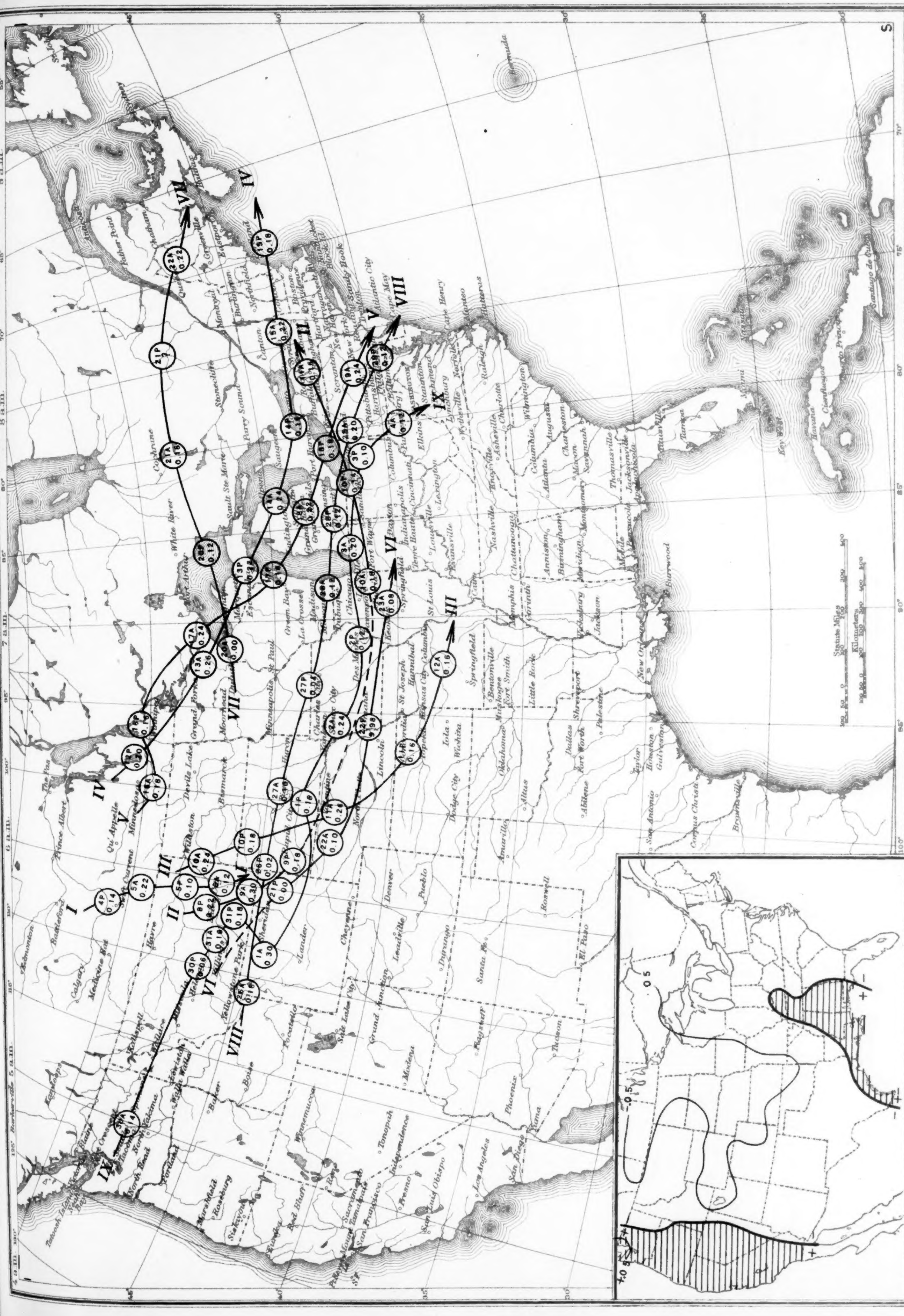


Chart II. Tracks of Centers of Cyclones, August, 1924. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by Wilfred P. Day.)

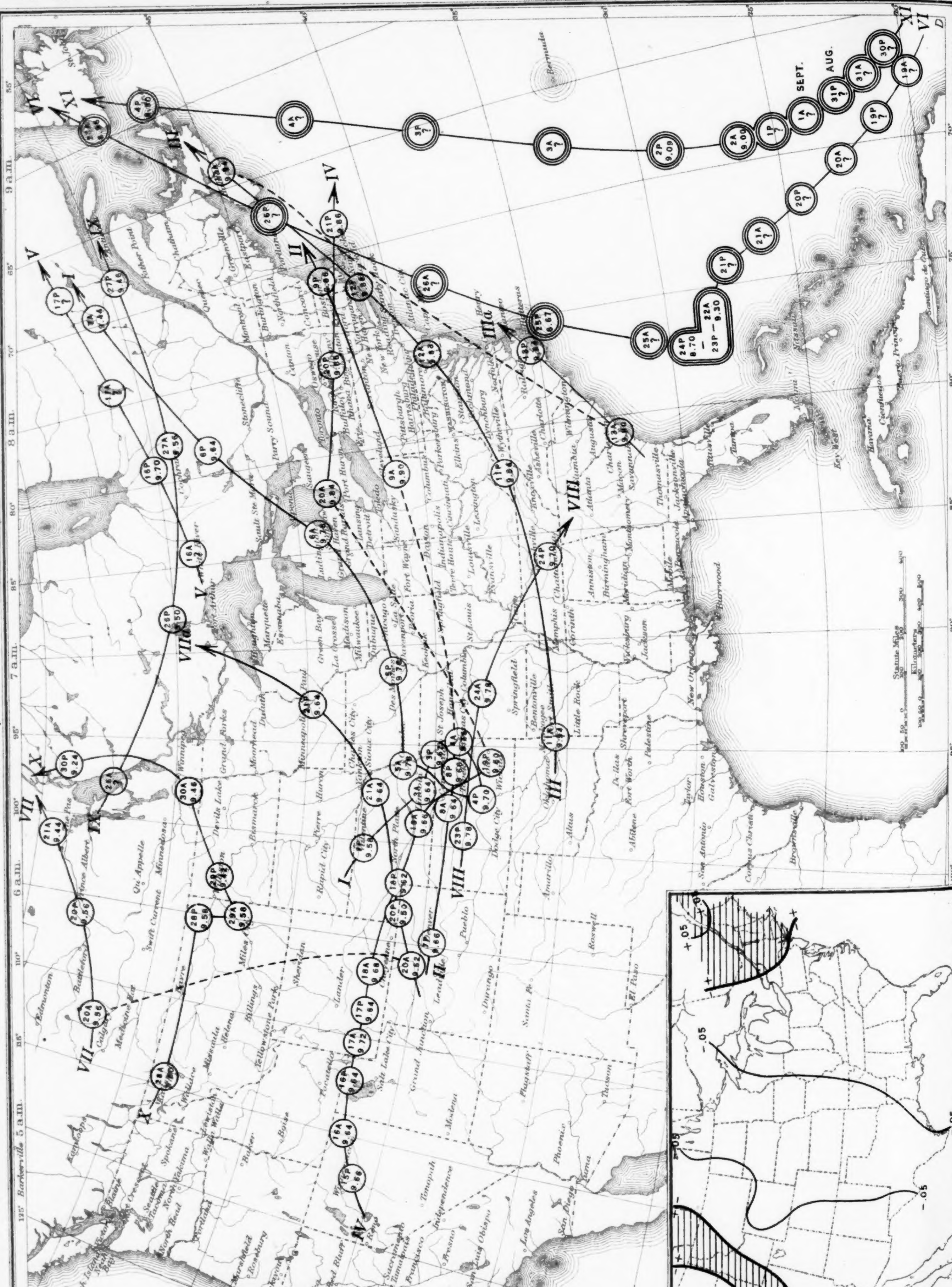
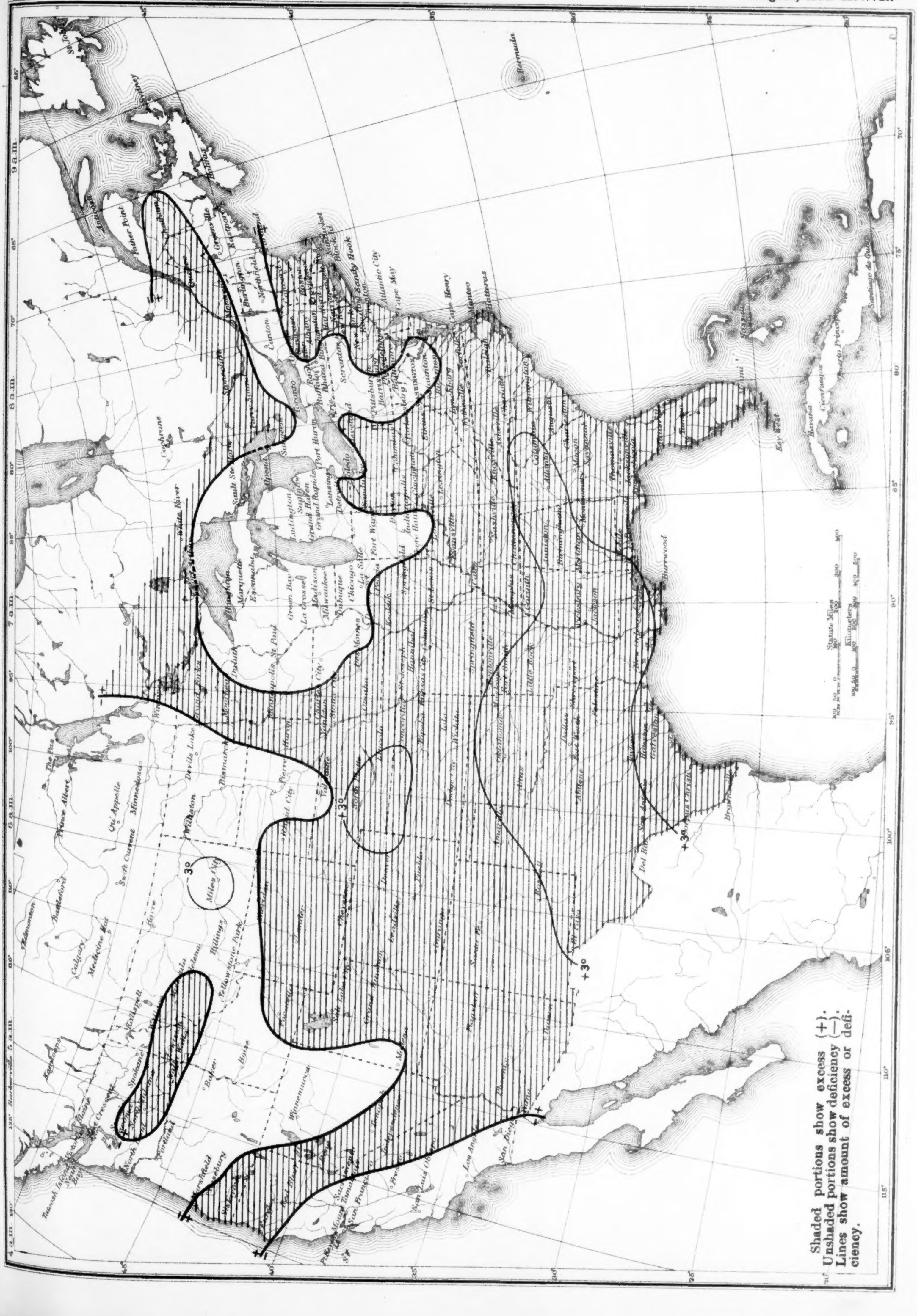


Chart III. Departure (°F.) of the Mean Temperature from the Normal, August, 1924

Chart III. Departure (°F.) of the Mean Temperature from the Normal, August, 1924



Shaded portions show excess (+).
Unshaded portions show deficiency (−).
Lines show amount of excess or deficiency.

Chart IV. Total Precipitation, Inches, August, 1924. (Inset) Departure of Precipitation from Normal

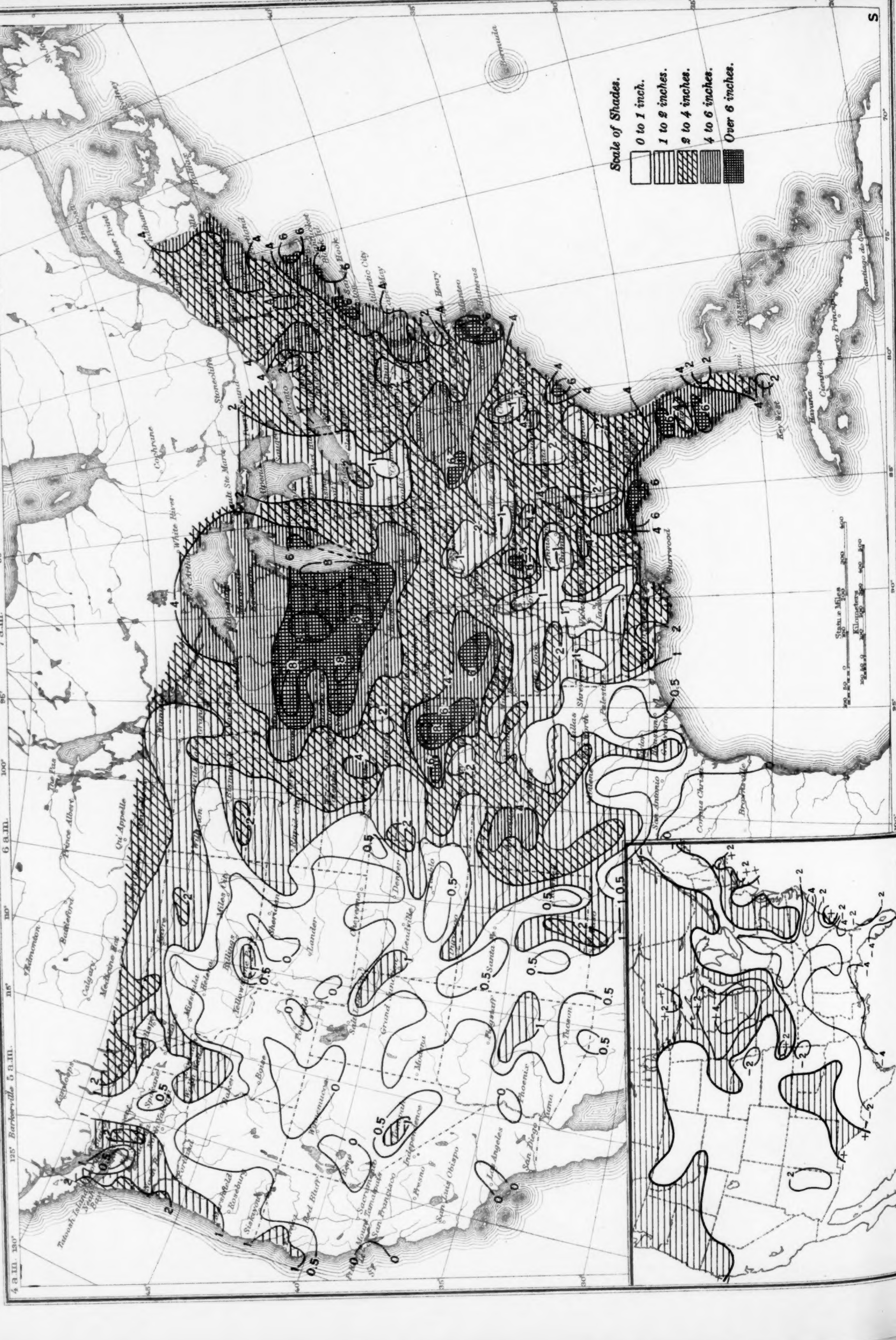


Chart V. Percentage of Clear Sky between Sunrise and Sunset, August, 1924

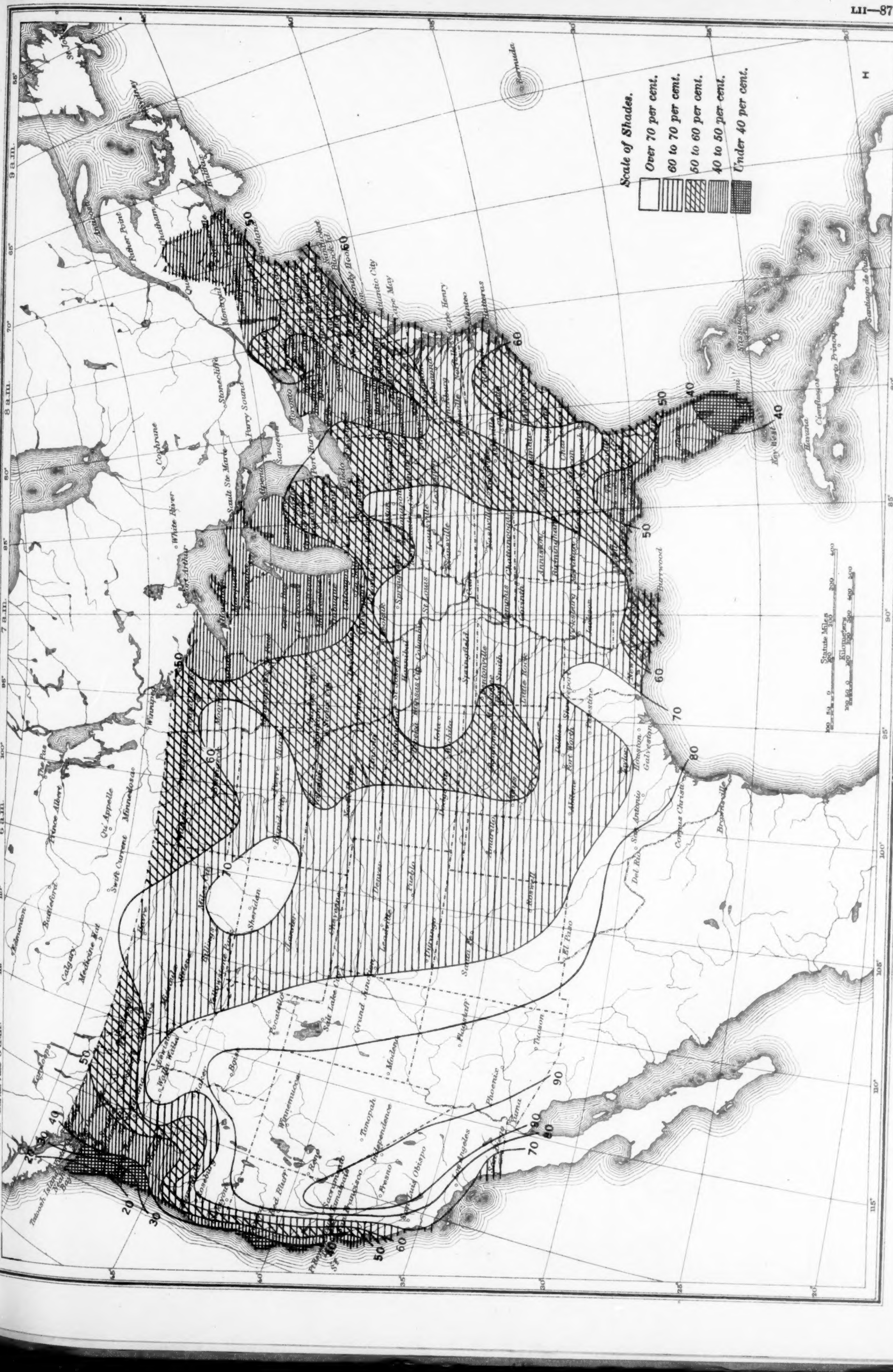


Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, August, 1924

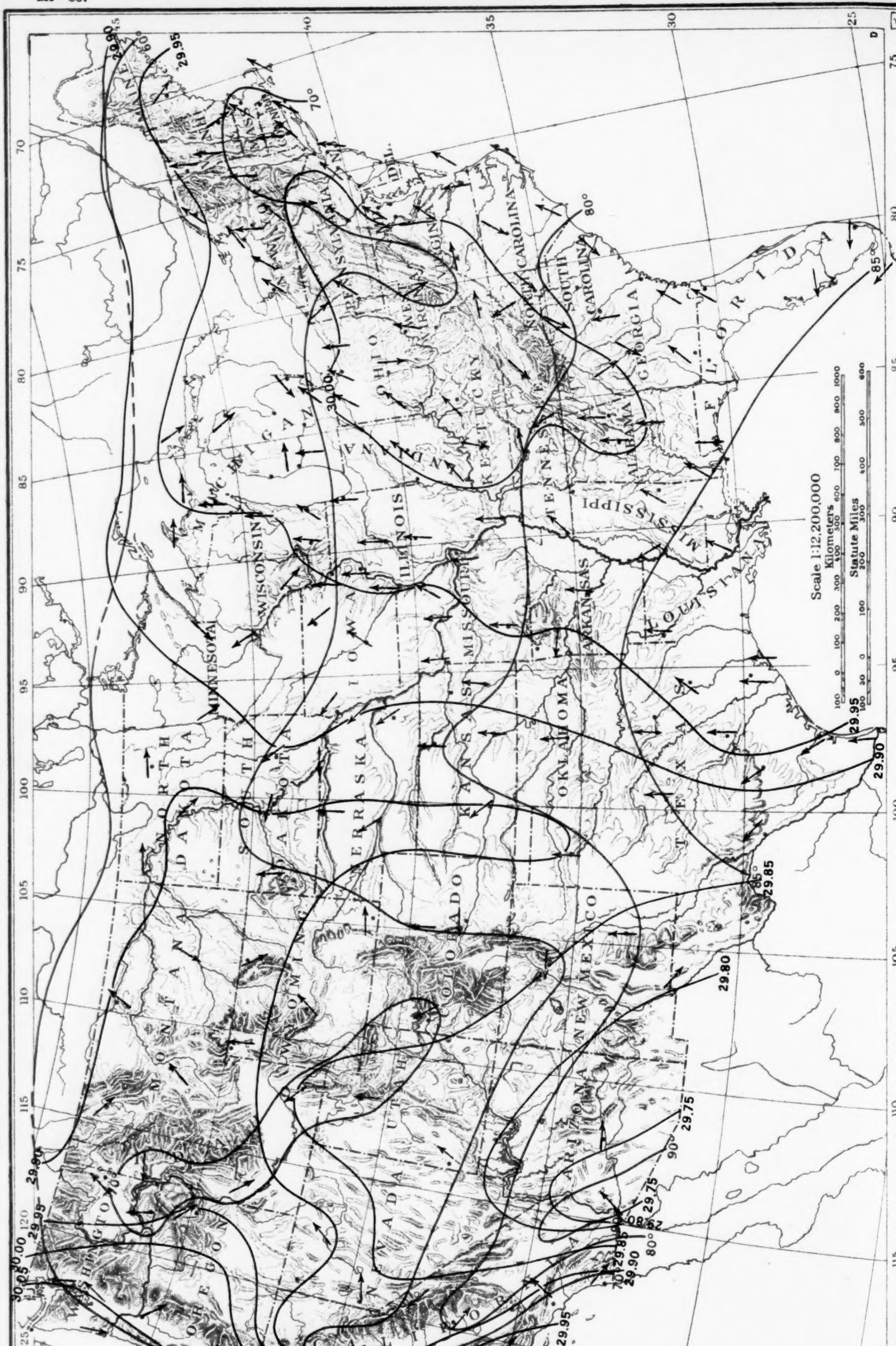


Chart VIII. Weather Map of North Atlantic Ocean, August 21, 1924.
(Plotted by F. A. Young.)

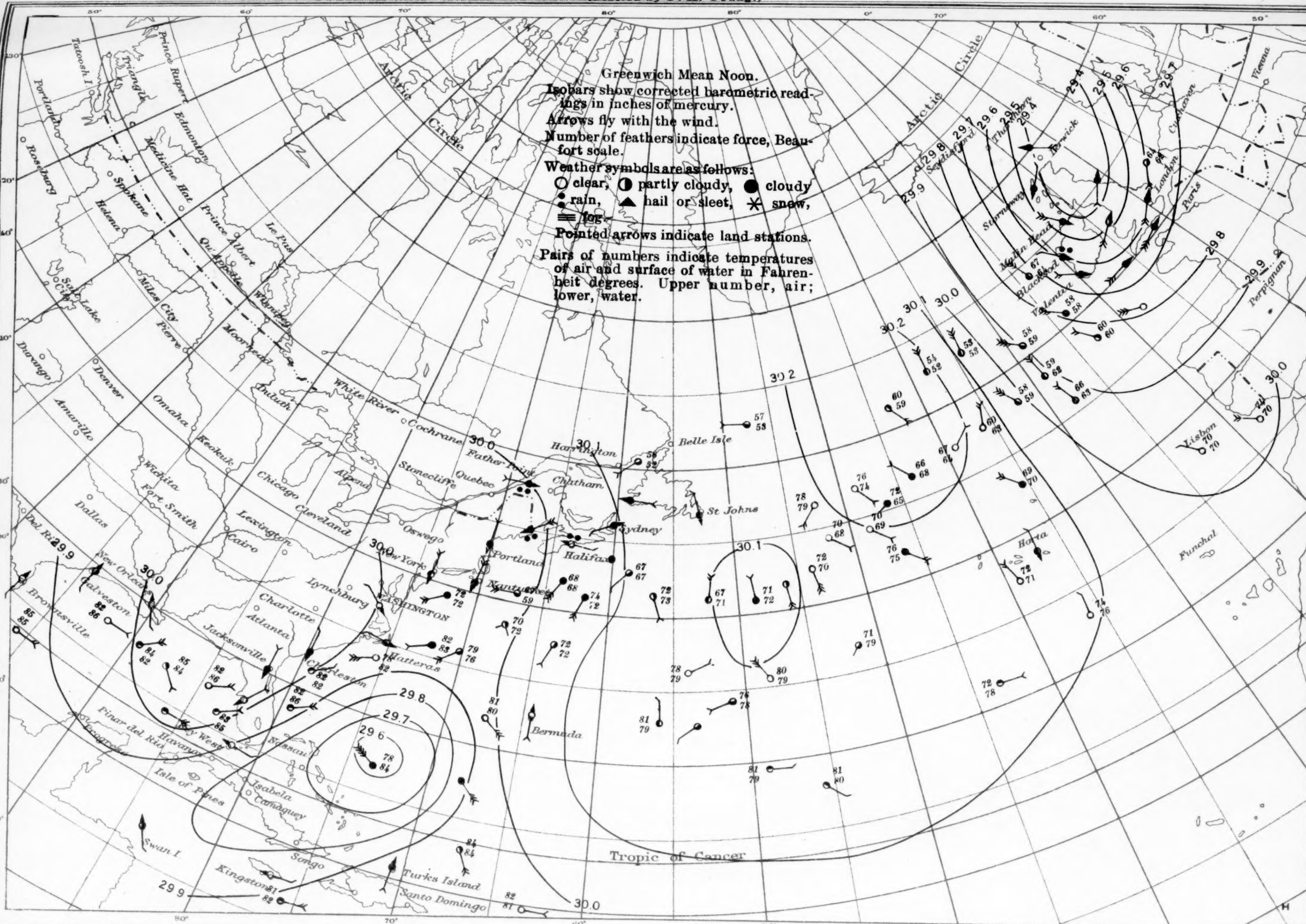
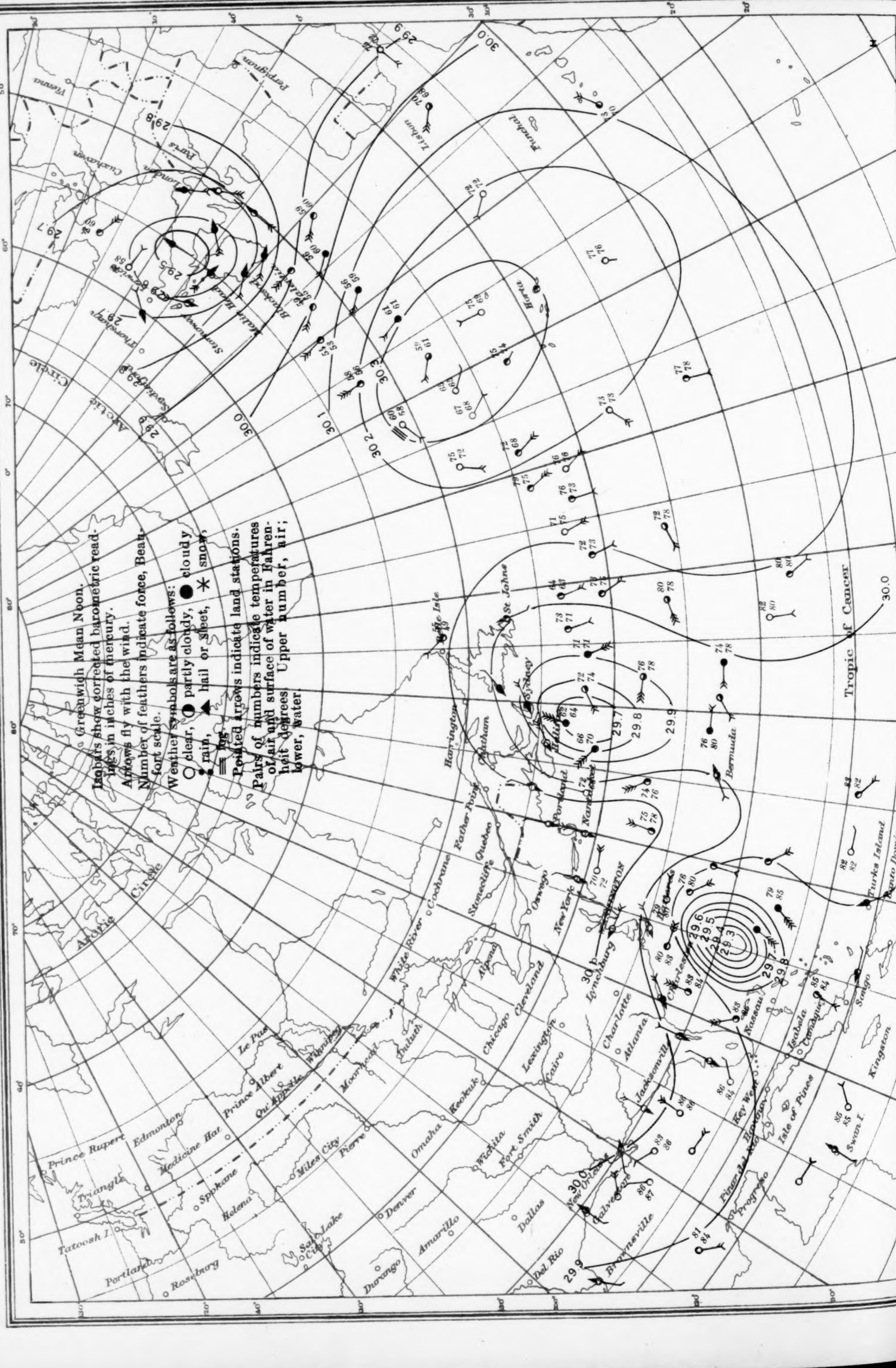


Chart IX. Weather Map of North Atlantic Ocean, August 22, 1924

(Plotted by F. A. Young.)



Weather Map of North Atlantic Ocean, August 23, 1924.
(Plotted by F. A. Young.)

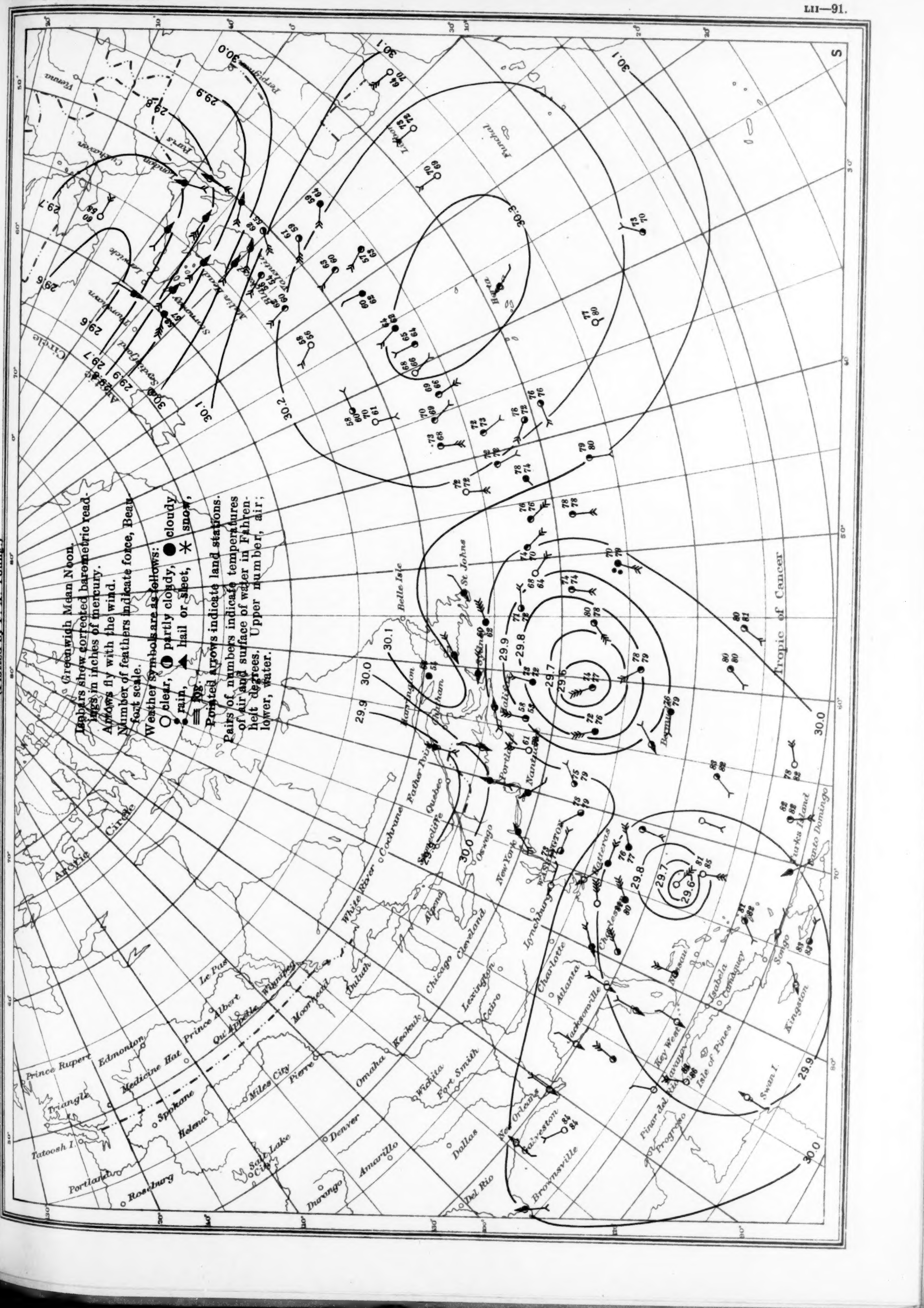
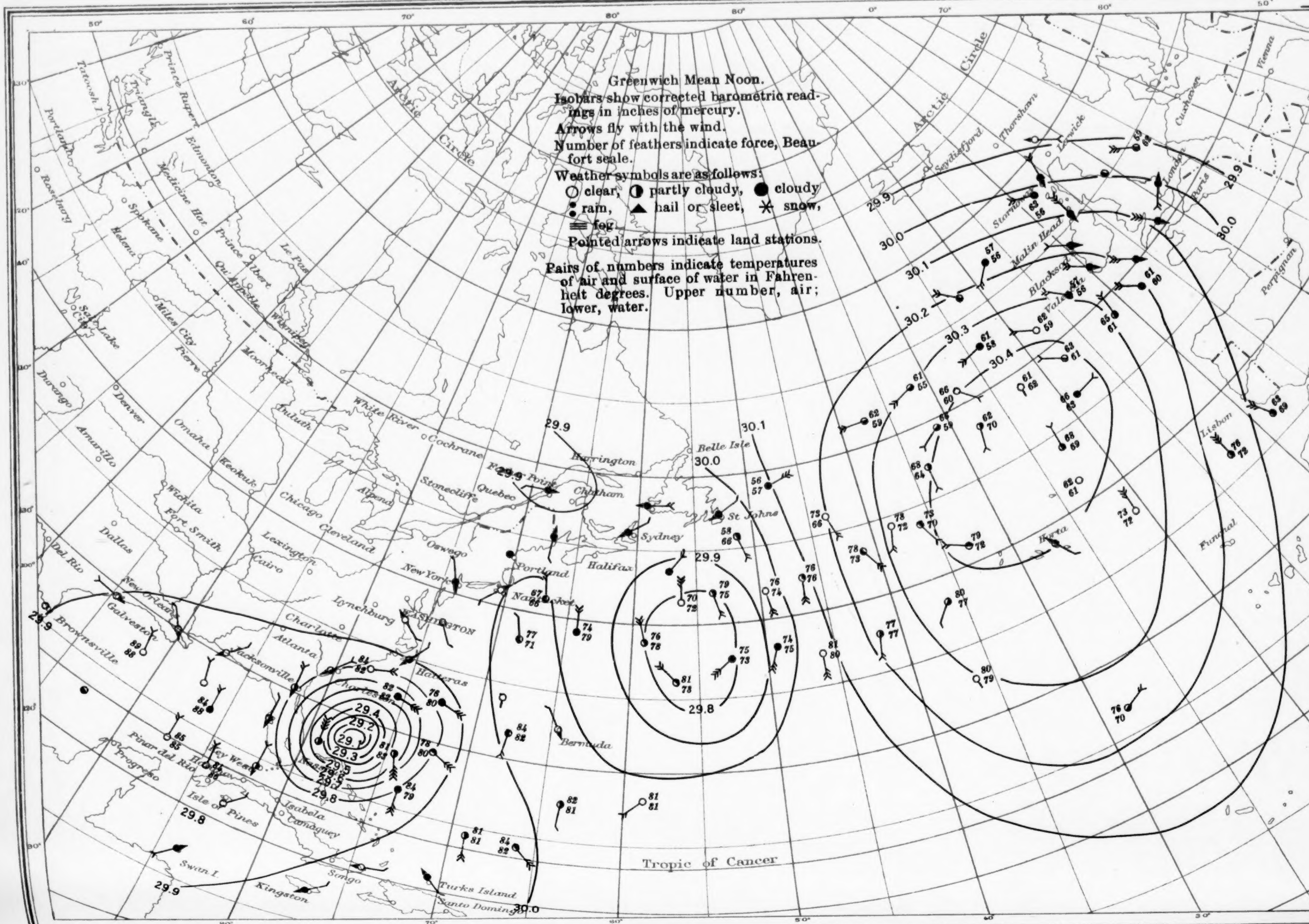


Chart XI. Weather Map of North Atlantic Ocean, August 24, 1924.

(Plotted by F. A. Young.)



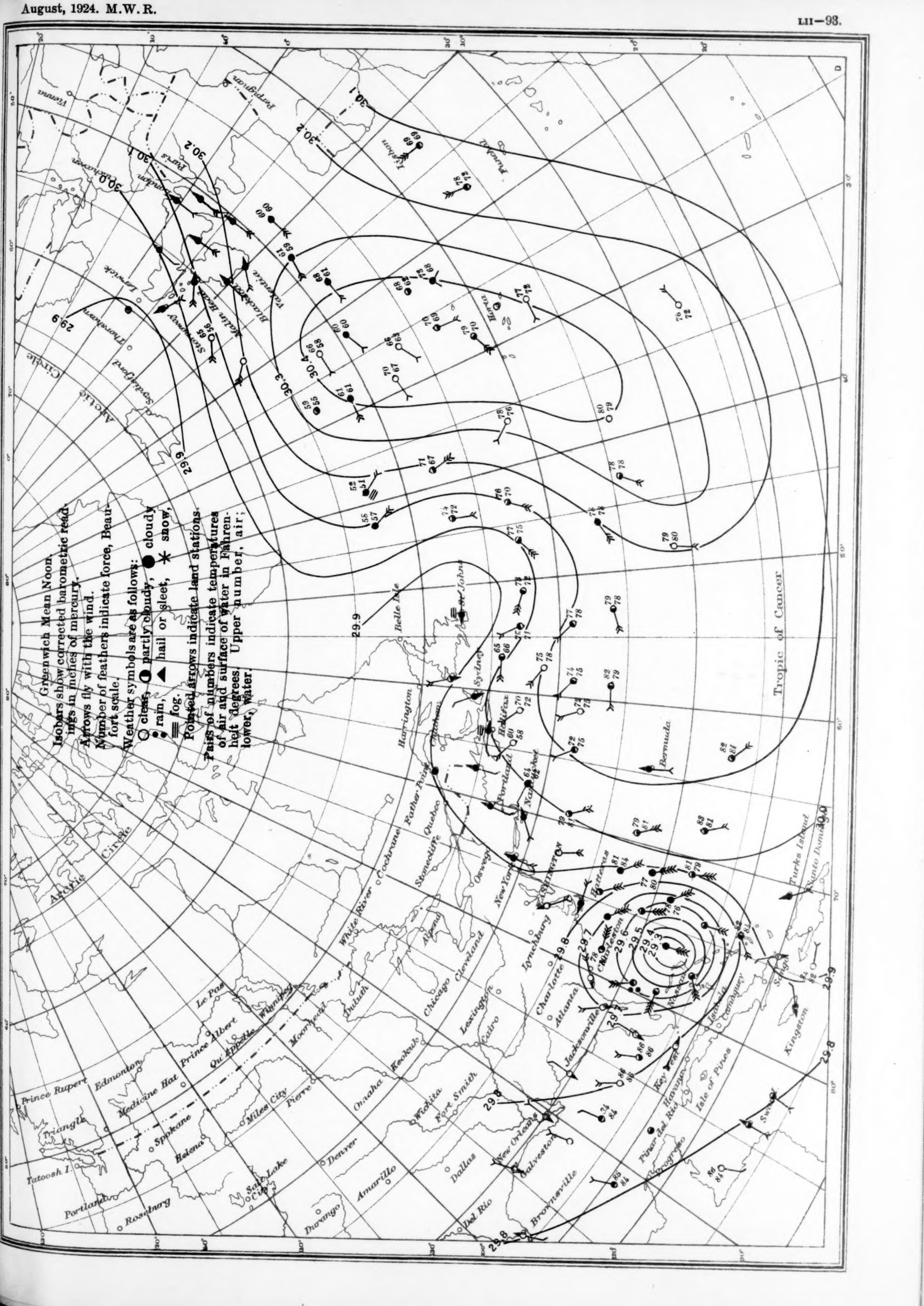
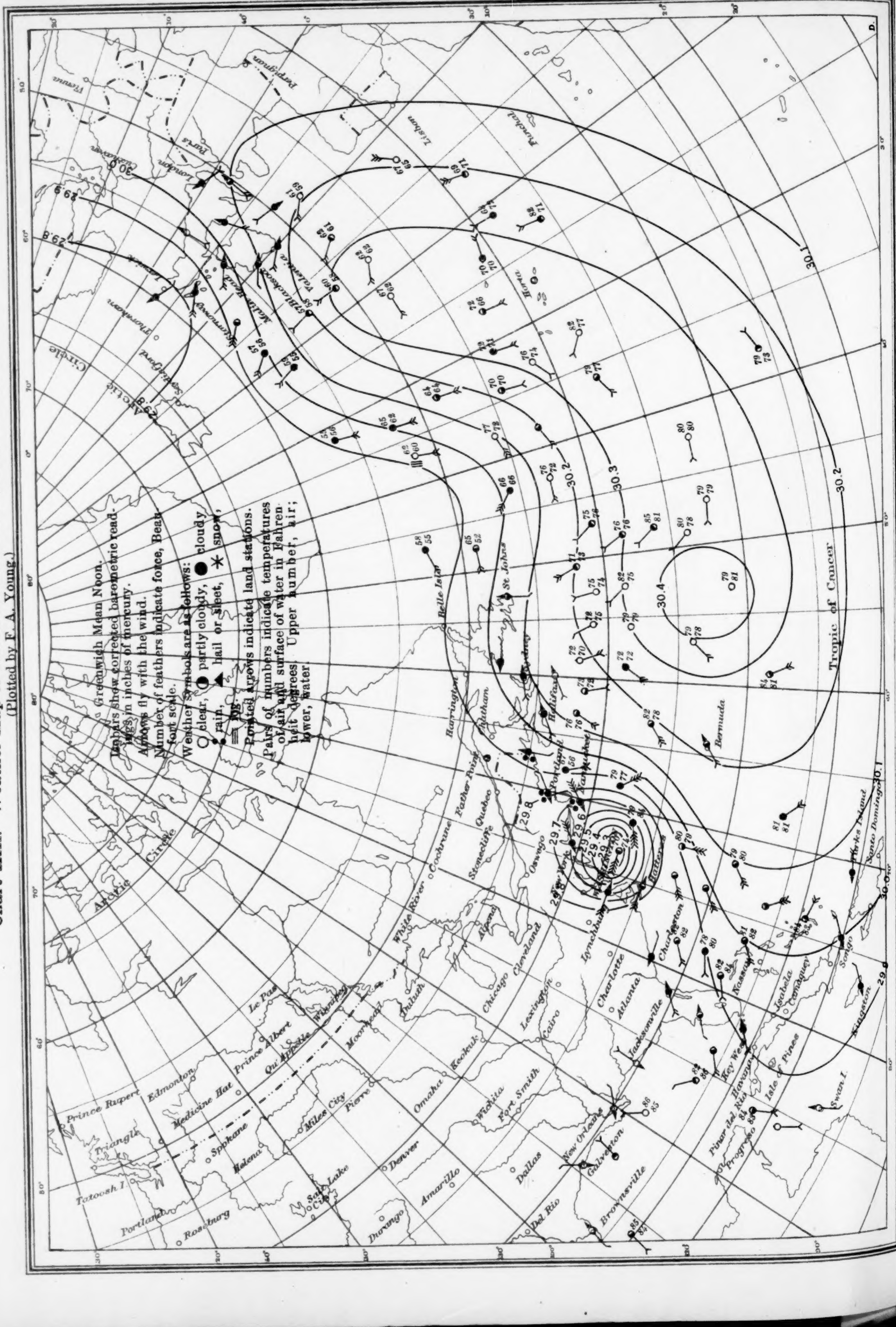

(Plotted by F. A. Young.)
Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows: clear, partly cloudy, cloudy, rain, hail or sleet, snow, fog.
Pointed arrows indicate land stations.
Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.
Tropic of Cancer
Arctic Circle
Bermuda
Lisbon
Horta
Halifax
New York
Charleston
Jacksonville
New Orleans
Key West
Havana
Kingston

Chart XIII. Weather Map of North Atlantic Ocean, August 26, 1924.
(Plotted by F. A. Young.)



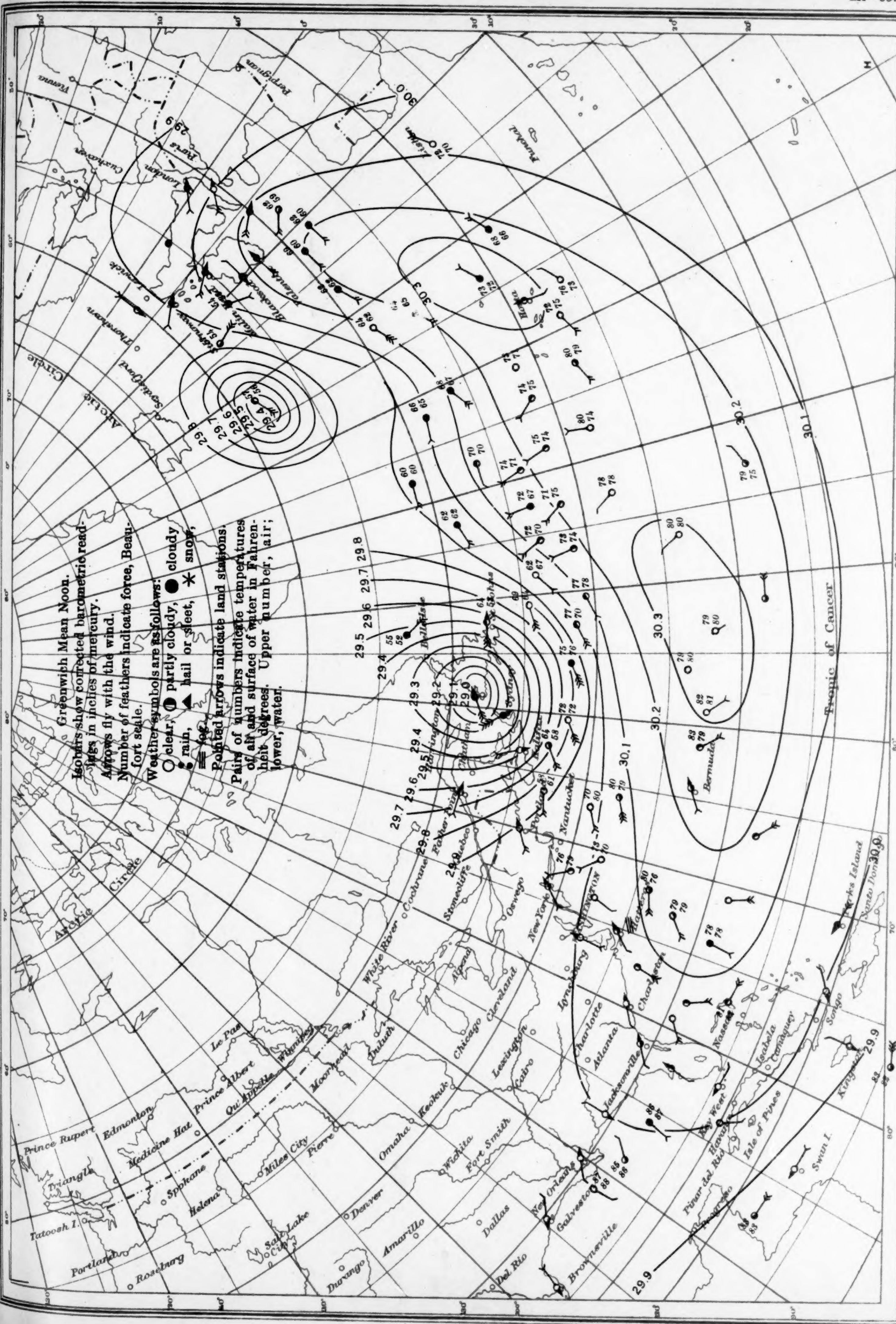

(Plotted by F. A. Young.)
Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy, rain, hail or sleet, snow, fog.
Pointed arrows indicate land stations.
Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.
Arctic Circle
Tropic of Cancer
Bermuda
Nantucket
Cochrane
Prince Rupert
Edmonton
Medicine Hat
Prince Albert
Winnipeg
Duluth
Chicago
Cleveland
Oswego
New York
Charlotte
Atlanta
Jacksonville
Key West
Havana
Nassau
Kingston
Swan I.
Isle of Pines
Pinar del Rio
New Orleans
Galveston
Brownsville
Del Rio
Dallas
Amarillo
Durango
Salt Lake City
Denver
Wichita
Fort Smith
Omaha
Keokuk
Lexington
Cairo
Pierre
Miles City
Helena
Spokane
Portland
Roseburg
Tatoosh I.
Triangle
Moorhead
Le Pas
White River
Sonago
Isabela
Camaguey
Turks Island
Santo Domingo
Father Point
Quebec
Paris
London
Cuxhaven
Lerwick
Thorshavn
Valencia
Blacksod
Stornoway
Horta
Funchal
Lisbon
Perpignan
Vienna

Chart XV. Weather Map of North Atlantic Ocean, August 28, 1923.

(Plotted by F. A. Young.)